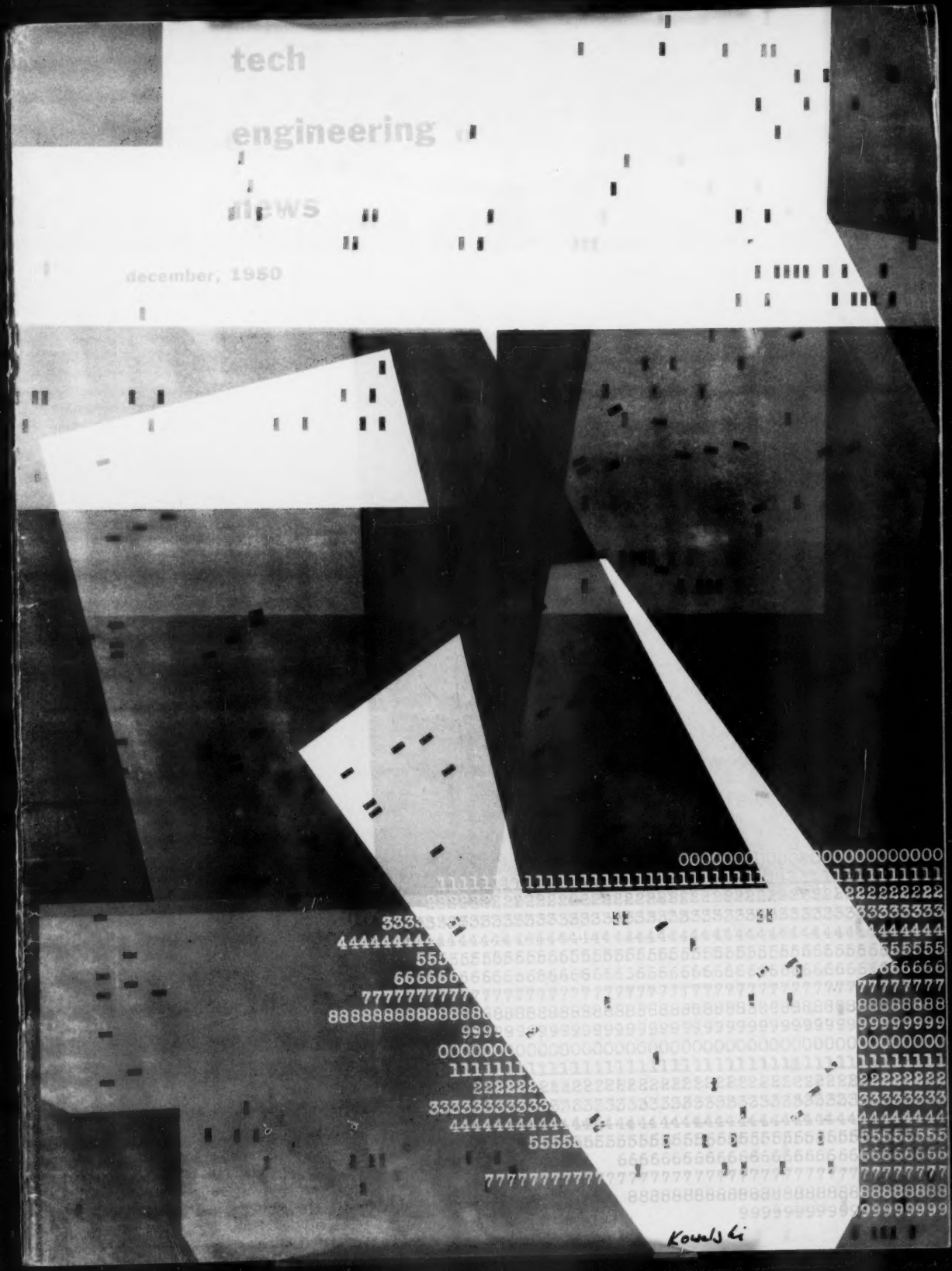
tech
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december, 1950
Kowalski

CARGO: Big Business for Little Businessmen!

YOUR Mobilgas dealer has a stake in this tanker—and in *all* facilities we own or charter. So do 46,400 dealers and jobbers like him!

For fine quality product, efficiently supplied, competitive in price, is the very life-blood of "little" business, any business.

Here, in effect, our tanker is a cost-cutting tool for "little business"—helping to keep gas and oil prices down, business volume up.

The same thing is true of Socony-Vacuum's modern laboratories—the advanced refining methods and equipment with which we work to produce the *most* product of *highest* quality at *lowest* cost.

In short, your Mobilgas dealer—an independent local businessman—can offer the quality, price and other benefits you want—because of the efficient, integrated structure that supplies him.

YOUR NATION
depends on strong industries . . .

YOUR INDUSTRIES
are only as strong as your Companies

YOUR COMPANIES
are only as strong as their ability to give you

Your Biggest Money's-Worth!

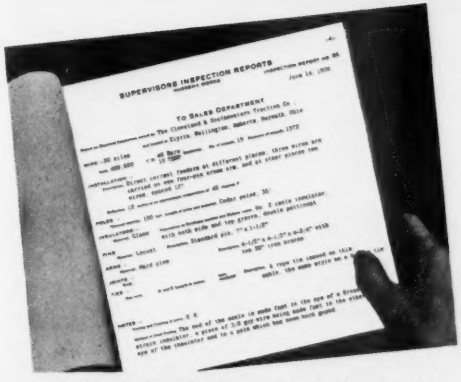
SOCONY-VACUUM

The Sign the Nation Knows . . . Builds as the Nation Grows!

SOCONY-VACUUM OIL COMPANY, INC., and Affiliates: MAGNOLIA PETROLEUM COMPANY, GENERAL PETROLEUM CORPORATION

A CARLOAD OF IMAGINEERING

That gondola of 954,000 *circ. mil.* Alcoa ACSR (Aluminum Cable Steel Reinforced) is only one of forty-five similar carloads for one 230-kv transmission line.



SUPERVISORS' INSPECTION REPORTS

June 14, 1906

TO SALES DEPARTMENT

Even before the first ACSR line was strung, Alcoa supervisors were on the job. The report above is dated June 14, 1906, covering the erection of all-aluminum conductors. Thus, the Alcoa "Book-of-Knowledge" has grown rich with on-the-job experience.

The two million miles of Alcoa ACSR that carry electricity across the country today are a product of Imagineering. Back in the 90's, Alcoa started with a fact: Aluminum is a good conductor of electricity.

Imagineering involved building labs long enough to mount whole spans of cable which would be vibrated and mauled as the wind does. It meant developing new basic data.

The lifetimes of many people and a good many dollars invested in "Imagineering" Alcoa ACSR speeded the more recent promotion of Alcoa E.C. Aluminum for manufacturers of insulated wire and cable. When the day comes that you are specifying industrial wire and cable you'll discover how Alcoa Imagineering brings savings in both cost and weight when you "Figure it in Aluminum." ALUMINUM COMPANY OF AMERICA, 742K Gulf Bldg., Pittsburgh 19, Pennsylvania.

ALCOA FIRST IN **ALUMINUM**

ALCOA ALUMINUM ®

THE NEW EQUITABLE SAVINGS AND LOAN ASSOCIATION BUILDING
IN PORTLAND, OREGON

Weather-conditioned with the nation's largest

HEAT PUMP

Equipped throughout for lasting efficiency with

JENKINS VALVES

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EQUITABLE SAVINGS & LOAN ASSOCIATION

Architect:
PIETRO BELLUSCHI

General Contractor:
ROSS B. HAMMOND CO.

Consulting Engineer:
J. DONALD KROEKER

Mechanical Contractor:
P. S. LORD

Air Conditioning System:
THE TRANE CO.

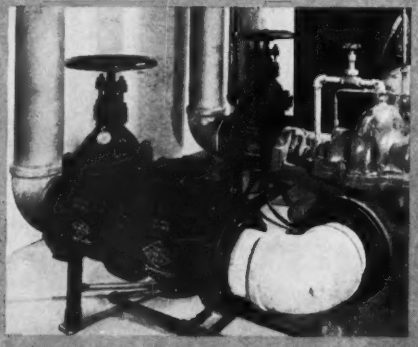
The new Equitable Building in Portland, Oregon, presents an impressive array of "firsts" in ultra-modern construction.

Most notable innovation is the reverse cycle refrigeration—the intriguing new "Heat Pump"—for all-year air conditioning. This superbly engineered system either heats or cools the building, as needed, and in certain seasons, provides heating in some zones, and cooling with humidification in others, both at the same time.

To be economically practical, this highly flexible system must operate with unfaltering efficiency. Every component was selected for dependable performance and exceptional durability.

The choice of Jenkins Valves, 582 in all, for all pump and convector lines, and for general pipelines as well, is significant. It is further proof that leading architects, engineers, and contractors rely on Jenkins whenever the installation must meet the highest standards of efficiency and economy.

These future-minded builders *pay no more* for Jenkins Valves; despite their extra value, the Jenkins Diamond is their guide to lasting economy; for new installations, for all replacements.



Sold through leading Distributors everywhere.

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JENKINS
LOOK FOR THE DIAMOND
VALVES
SINCE 1864
TRADE JENKINS MARK

Why they put a glass pipe line underneath Buttermilk Channel

If you've ever driven through a long tunnel, you know how hard the lights are on your eyes.

The reason is you pass under a succession of bright spots of light which are apt to take your attention from the road. And you're made uncomfortable by the reflection of these bright spots from the top of the car ahead.

But New York's new 9117-foot Brooklyn-Battery Tunnel—America's longest, built and operated by the Triborough Bridge and Tunnel Authority—has an amazingly different and better kind of tunnel lighting.

Instead of the disturbing flicker of lights placed at regular intervals, motorists enjoy bright and even illumination—practically daylight—every foot of the way beneath Buttermilk Channel and New York Harbor.

The pipe line for this flood of light is built of 3000 twelve-foot sections of Corning's Pyrex brand glass tubing. Each length of pipe is a self-contained light cartridge, with two slim fluorescent lamps inside.

Should one of the lamps die out, that cartridge is replaced with another, assembled and kept ready on a repair truck. And replacement is made as easily as you'd pop a new bulb into a light fixture in your home.

The twelve-foot sections of Pyrex pipe are only two inches in diameter, with walls only a quarter of an inch thick. But despite their slimness, they're so strong they can withstand washing with a high-pressure hose. They're so sturdy they're not injured by truck tarpaulins which sometimes work loose and slap against them.

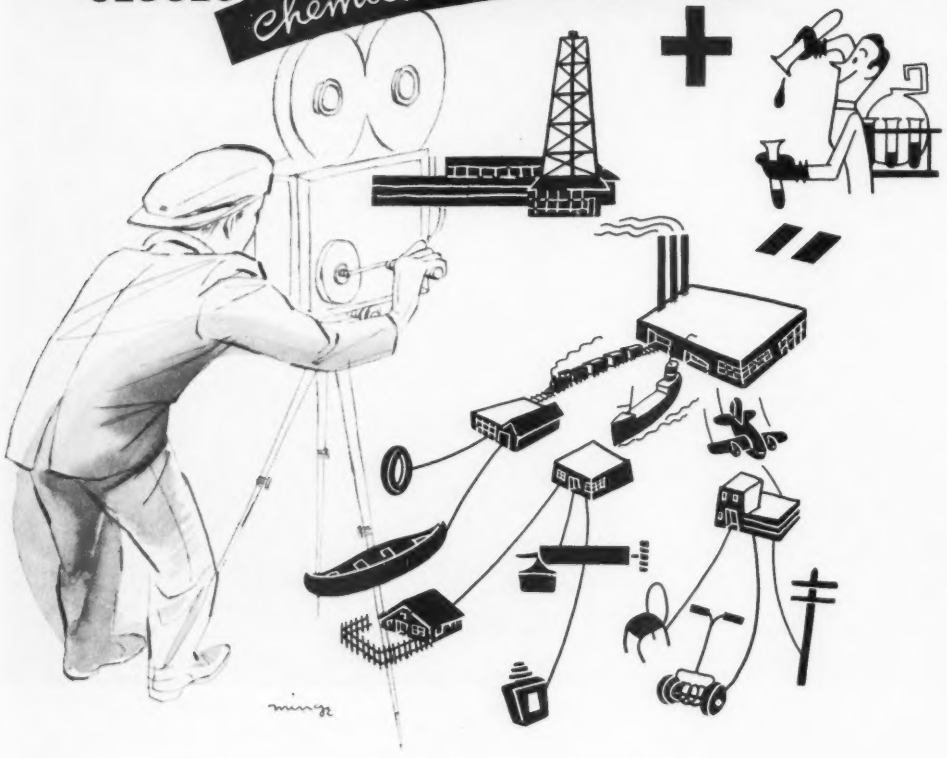
Designers of this new tunnel lighting system had no trouble finding a material needed to make it work because, years ago, Corning developed heat-resistant Pyrex pipe for industrial use.

Throughout industry, *Corning means research in glass*—research that has helped make glass a material of practically limitless uses.

So, when you're out of college and busy planning new products or processes, or improvements in existing ones, it will pay you to keep glass in mind. Then we hope you will call on Corning before your planning reaches the blueprint stage. *Corning Glass Works, Corning, New York.*

CORNING
means research in glass

CLOSEUP: chemical plant 1950



Ever take a close-up of a modern chemical plant in action . . . from research . . . through production . . . to the time the products are on the market? Let's take a look at Dow—one of the nation's leading chemical producers—by following just one product through the plant:

Dowtherm, for example, is a Dow-developed chemical for process heating. It brings accurate heat control and added safety not found in direct flame heating. Although Dowtherm is widely used already in many factory processes, Dow Technical Service and Research regularly aid in developing new applications for this outstanding Dow-developed heat exchange medium. Products now using Dowtherm in their manufacture include: nylon, plastics, varnish, vegetable shortening, soap, chemicals, asphalt, natural gas and fried noodles.

Once Dowtherm had proved itself in the laboratories, production took over to manufacture this important heat exchange medium for the processing plants of the nation. At the same time, the Dow sales department organized new service and distribution channels and gave special training to production engineers who would handle this new method for process heating.

Dowtherm is only one of over 600 Dow chemicals indispensable to industry and agriculture. Multiply the complexities involved in researching, producing and marketing this one product by several hundred in the Dow line and you will understand why a close-up of a modern chemical company reveals one of the industrial achievements of the twentieth century.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Atlanta • Cleveland • Detroit
Chicago • St. Louis • Houston • San Francisco • Los Angeles • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

DOW

CHEMICALS

INDISPENSABLE TO INDUSTRY AND AGRICULTURE

THE DU PONT DIGEST

The Teflon* Problem:

Given a plastic for which there is no known solvent, how would you turn it into a coating?

Some time ago Du Pont research discovered a new plastic—"Teflon" tetrafluoroethylene resin. It had temperature resistance beyond the range of any previous plastic, excellent electrical characteristics, and the highest degree of chemical inertness among commercial plastics.

But tough-guy "Teflon" was almost *too* tough. It wouldn't melt and flow like other plastics. Hence, it could be molded only in simple shapes. There was no existing technique by which it could be made into thin coatings. Unless this difficulty could be overcome, the very properties that made "Teflon" so promising narrowed its usefulness.

"Teflon" Won't Dissolve

In the past, problems like this have been handled by dissolving plastics in a suitable solvent and using them as the base for enamels and similar coatings. But "Teflon" will not dissolve in any solvent yet known. It even stands up to nitric acid.

At this point Du Pont physical chemists suggested dispersions—minute particles suspended in a liquid—as the answer. After much study, scientists of the Polychemicals Department learned how to suspend "Teflon" particles about 1/125,000 of an inch in diameter. Aided by the fundamental studies of Chemical Department scientists, they devised today's commercial scale process.

Meanwhile Du Pont's Fabrics and Finishes Department was keeping pace with the development. Their contributions to formulating the new products did much to establish "Teflon" polytetrafluoroethylene coatings and wire enamels in many special uses.

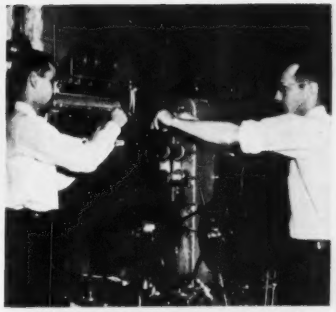
In electric motors, for instance, these enamels are used on wire so the motor can be operated at higher temperatures and will deliver more power per unit of weight. Such motors are more compact and sometimes cost less.

Other uses include non-sticking coatings that cut costs when applied to bakery rolls, rubber molds, heat-sealing machinery and similar equipment. Corrosion-resistant "Teflon" coatings for special uses are currently being investigated.

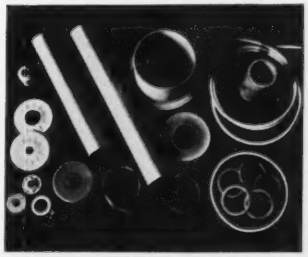
Product of Teamwork

"Teflon" finishes are a typical fruit of the close teamwork of Du Pont technical men of diverse backgrounds. Organic and physical chemists played a major role. Physicists participated by developing fundamental information on the nature of the dispersion. Chemical and mechanical engineers designed the manufacturing apparatus. Working together, they made possible this new and important addition to the Du Pont family of "Better Things for Better Living . . . through Chemistry."

*Reg. U. S. Patent Off.



Philip S. Sanders, *left, A. B. in Chemistry, University of Pennsylvania, 1944, supervises operation of a special dipping machine used to coat wire with "Teflon" enamel in the laboratory. Enamel is "dried" by fusing.*



Number one *plastic in resistance to heat, chemicals and moisture, "Teflon" is shown in forms of gaskets, coaxial cable spacers, tape, rod, pipe, flared tubing, valve stem packing beading as it is supplied to industry.*

In a test *of heat resistance at 390°F., the "Teflon" rod (right) remains intact while two other plastics melt or swell out of shape.*

DID YOU KNOW . . .

. . . 76 students at 47 universities are currently pursuing post-graduate work as holders of Du Pont Fellowships in science. Awards for 1950-51 total $224,000.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Great Dramatic Entertainment—"Cavalcade of America," Tuesday Nights, NBC

tech engineering news

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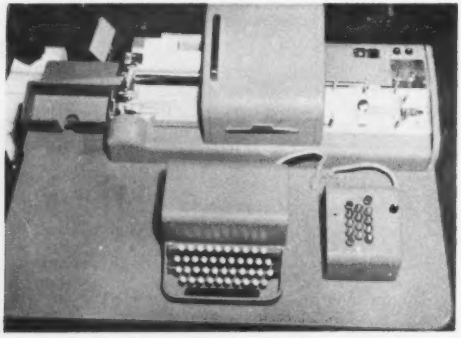
statistics and machinery

The IBM Saga

By Edward F. Leonard, '53

In the middle of the last century, accounting and statistical operations of several larger enterprises were beginning to reach a stage of complexity which precluded the rendering of reports within any reasonable amount of time. It was only when long and stubborn attempts to shorten preparation time by modernization and simplification of procedures failed, that the basic problem was recognized and attacked. The individual who spearheaded this attack was an employee of the United States Bureau of Standards, Charles Hollerith.

Hollerith had been closely associated with the activities of the Bureau for some time when the Department of Commerce began seeking a faster means for performing statistical analyses in connection with the census



Pictured above is the IBM Alphabetic-Numeric Key-Punching Machine. All information analyzed on IBM machines must be placed on IBM cards in punched form. This machine normally performs this punching operation.

of 1890. It had become obvious that the census was becoming too large an enterprise to be handled by previous methods; it was estimated that it would be time to take the census of 1900 before all the data of the 1890 census was compiled and analyzed. Hollerith's solution to this problem, which was immediately accepted by the Department, was the forerunner of modern IBM punched-card machinery. In the Hollerith machine, information was punched on a tape which actuated electromagnetic pickups as it passed through the machine. The only basic change in operating principle is the substitution of individual punched cards for the punched tape.

Many of the developments which distinguish the modern machine from its predecessor were effected after International Business Machines Corporation acquired the rights to Hollerith's machine. All IBM punched-card accounting machines are owned by the company and leased to the companies or institutions using them. The following discussion will confine itself to a consideration of the objectives, design, and operation of these instruments, along with examples drawn from the files of the M. I. T. Statistical Services.

The fundamental unit of the whole system is its namesake — the punched card. On the card is punched information of two types — information which is to be recorded or treated in one or more of many ways, and instructions to the machine as to what to do with the information provided.

Information may be punched onto a card in one or more of several ways. By use of the key punch machine, an operator may transfer written information into punched information in alphabetic and numerical form by depressing the proper keys on a modified typewriter keyboard. The machine automatically positions and stacks the cards as the operator continues to transfer information. If some or all of the information is already on another set of punched cards, it is automatically transferred to the new set by means of the reproductory punch. Through proper and successive application of this device, it is possible to transfer parts of information recorded on several cards onto one new card. Another method of automatically putting information on cards is the mark-sensing feature. (Mark sensing is the process of perceiving pencil markings on one or more rows in several columns of a special card. Electromagnetic devices in the mark-sensing machine are effected by the conductivity of the marked areas and transfer the information to the punching apparatus.)

Usually all information placed on cards is checked by a process of verification. To perform this operation the cards are compared directly with the original source of information. If the original information was transcribed by a key-punch operator, the operator may perform the operation again as the cards are automatically fed through the verifier. In the case of a discrepancy, the flow of cards stops and the machine issues a warning. The operator then punches the proper keys once more. If the information on the card still does not agree with the punched information, the card is ejected. All cards not ejected are notched as an indication that they have been verified. An alternate, and sometimes more desirable, method is to pass the cards through a tabulator and visually compare the printed information with the original text.

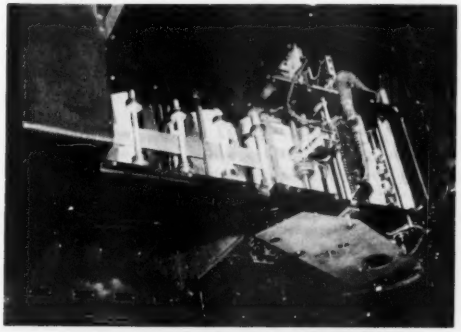
The information now appears on the card in a series of eighty vertical columns of twelve rows each. Each column which contains information has one or more holes punched; if the information is numerical, one hole, representing a digit from zero to nine, is punched. If the information is alphabetical, however, two holes are punched in each column.

To record one of twenty-six alphabetic characters in a column where only twelve positions are available, it is necessary to use two digits in the same column. For this reason, the alphabet is originally broken up into three groups of nine, nine, and eight characters. The group into which each letter falls is indicated by a punched hole in the zero, eleven, or twelve row. Then the particular character in the group is distinguished by the second number — from one to nine — which is punched.

Instructions to the machine are usually given in the

eleven or twelve row in specially-assigned instruction columns.

Frequently, newly punched cards must be sorted according to a function of some factor recorded on one



Most operations in which cards are passed through IBM machines are preceded by a selection of the desired cards. This selection is most quickly performed by a sorter. The machine pictured processes 27,000 cards per hour.

or more rows of the card. This operation is most efficiently performed by a sorter, a device which separates the cards into as many as twelve separate groups, representing all possible groups in a single-punched column. Obviously, it is necessary to sort twice to completely separate an alphabetic column, and for this reason, cards with alphabetic information are often assigned alphabetic sequence numbers which can be distinguished in considerably less time.

Another frequent operation is that of interpretation. The interpreter takes information from the punched card and prints it in two rows on the card. It is possible to arrange information punched on the card in any desired printed array; there are one hundred twenty possible positions for a maximum of eighty characters. The machine will print both alphabetic and numeric information.

One of the more versatile of the statistical devices is the "collator." A collator will select cards from a stack with respect to being larger than, smaller than, or equal to, one or more punched digits. By means of these three basic powers of perception, a collator will select cards, check their sequence, perform the reverse operation of selection — that of merging, and will match prearranged columns of one set of cards with selected columns of another set of cards. All of these operations can be performed in one step with respect to digits in sixteen columns.

Another of the more versatile statistical devices is the accounting machine. This machine, alone and combined and used in conjunction with other equipment, performs a multitude of operations — primarily selective printing of data either directly from cards or computed within the machine from data on the cards. In general this machine limits its computational activities to addition and subtraction.

To complete the discussion of the various machine classifications we shall consider the automatic reproducing punch. These exist in several forms. They take information computed on the accounting machine from a set of cards and summarize results on separate cards; they perform an operation called "gang punching," the reproduction of all or part of the information on one card upon cards which immediately follow it through the machine; they transcribe mark-sensed information, and perform various comparisons. An allied device, the calculating punch, performs the four basic arithmetic processes of addition, subtraction, multiplication, and division, and expands these fundamentals through programming, comparison, and controlling operations.

While the previous discussion attempts to indicate an orderly sequence in the use of the machines, practice presents such a tremendous variety of cases that it is quite impossible to dictate a definite sequence of operation for jobs. It should also be noted that while certain limitations are placed on the number of digits or the number of operations that can be handled by a machine at one time, many extremely long and complicated problems can be solved through combinations of equipment or repeated application of basic processes. Thus even the solution of differential equations is generally possible by the conversion of the equation to a difference equation and the repeated application of the basic arithmetic processes. Further, reference to Table I will show that while many operations can

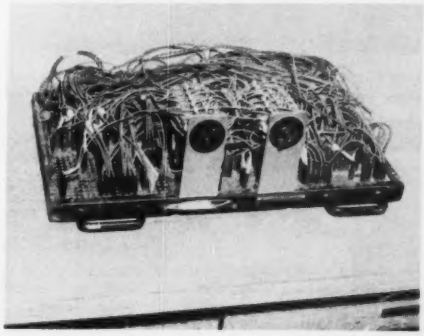
TABLE I

Representative Speeds for IBM Punched-Card Machines[1]

(All machines require 0.65 sec. to eject a card)

Duplicating Attachment	420 cards/hr.
Manual Key Punch (approximate)	5,000 col./hr. (80 col./card).
Verifier	Same as duplicator and manual key punch.
Interpreter	3,600 cards/hr.
Sorter	27,000 cards/hr.
Collator	12,000 cards/hr. (24,000 cards/hr. for certain single feed mechanism processes.)
Accounting Machine	
Listing	4,500 cards/hr.
Tabulating	9,000 cards/hr.
Reproducing Punch	6,000 cards/hr.
Calculating Punches	1,000 to 3,000 cards/hr. depending on number of digits.

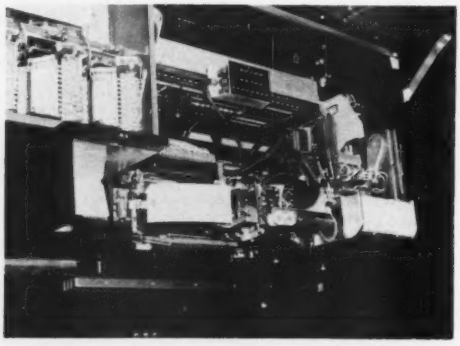
1. From *A Description of the IBM Punched Card System*, F. M. Verzuh, MIT Statistical Services, February, 1950.



The brain of most IBM machines takes the form of a control panel. Pictured above is one of the larger panels constructed by the MIT Statistical Services. Note the switches, permitting multiple operations from one panel.

be performed on more than one machine, greatest speed can be obtained for a specific operation on one specific machine. Another factor which dictates the selection of a machine for a particular job is the possibility of combining operations and computing supplementary information so that one feed through the machine is all that is necessary. A consideration of basic operating principles will serve to illustrate these statements.

Since facts recorded on the punched cards are distinguished from one another by their columnar and row positions, any device which is to accept these facts into the machine must take cognizance of both row and columnar positions. In the machines under consideration this is done allowing the card to pass under a set of eighty wire brushes arranged in a row perpendicular to the motion of the card through the machine. Each brush is responsible for recording the punched positions on its respective row by making an electrical contact through the punched card with a metal surface below the card. The motion of the cards beneath the brushes is synchronized with a set of revolving contacts connected to the brush circuit so that the punched holes, moving forward with constant velocity, pass under the brush at the same time that the brush circuit is in contact with the terminal corresponding to the number. If instructions punched on the card are to dictate which one or more of several operations are to be performed on the particular card, the card is usually caused to pass through two sets of brushes. The first set then receives the instructions and causes the proper circuit to be closed. Thus, if certain columns on several cards are



Most mathematical problems are handled in the versatile calculating punch. This machine will add, subtract, multiply, and divide. Approximate integration and differentiation is also possible on such machines.

to be added, the answer to be subtracted from a quantity on a subsequent card, and the result to be punched on another card, it is only necessary that a control row on the cards be selected and three numbers selected to indicate the desired operation. As each card passes through the first set of brushes, the proper circuit is closed by the punched hole and the operation is performed. Thus it is seen that all subsequent operations are controlled either by predetermined fixed settings or by the stimuli from the control brushes. In like manner, all information is provided either by the cards or by information wired into the machine for the duration of the operation. It is easily seen from this discussion that the machine performs predetermined operations and derives its versatility from a variable control panel.

The control panel on IBM statistical machines takes the form of a large plastic rectangular parallelepiped with an approximate thickness of one inch and surface area grounded by sides ranging from about nine to eighteen inches square. Perpendicular to the surface and drilled at regular intervals are numerous small holes which will accept specially designed jacks. On the surface and adjacent to these holes is an identification of each group of holes printed in silver.

In practice, the control panel is removed from the machine for wiring. Wires with jacks at each end then are arranged on the panel so that impulses are directed from one or more parts of the machine to one or several other areas. It is in this section that the machine's seat of versatility and the channel for the receipt of human instruction is located. Through any one of many combinations, numeric or alphabetic information from one set of cards may be led through several operations of comparison, arithmetic treatment, and classification, recording the results on counters, punching them onto the original card, or punching them into separate cards either in a separate pack or trailing the original card. Results may also be used to actuate a sorting or merging mechanism which alters the position or order of either the original cards or other cards being simultaneously run through either the first machine or another machine connected to the circuit.

The design and nature of the equipment indicates that by far its greatest use will be either in direct recording, requiring little or no mathematical treatment, or in the preparation of large quantities of facts to be combined according to some mathematical function. Basic accounting procedures are usually included in the former classification. Debits and credits of individual accounts along with sales information, discount procedures and allied information are included along with either the name or identifying number of the account on cards which are filed according to a predetermined order. Maintenance of such a system usually amounts to the merging of new accounts into the files, insertion of credits and debits with respect to the individual accounts, and the periodic compilation of the information contained in the files. Thus normal operations would include the computation of monthly bills, with the automatic computation of discounts and any special charges, the automatic balancing of books, the automatic printing of monthly, periodic, and annual statements, and general and specific information as required by individual organizations. It is interesting to note that so long as information is recorded on the cards, it may be made available in any desired form. It is not necessary to prepare the cards in any special way so that, as an example, all customers buying a particular product in a single month could be listed.

From this fact it is seen that if a company has itemized its shipments on punched cards and later finds that a certain product which has been shipped is defective, the customers receiving the defective article can be discovered and notified in an extremely short period of time. Manual examination of documents, on the other hand, could require so great a period of time that the error could not be corrected in time.

At Technology this selective principle allows various offices — Admissions, Dean's, Registrar's, Bursar's, Medical — to prepare lists containing all students falling into any classification, in any desired order. From the current cards now on file will come the student

(*Continued on page 25*)

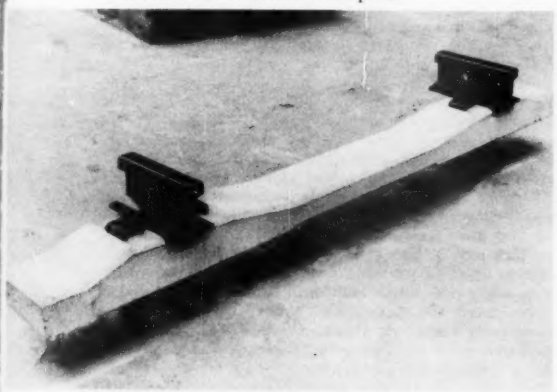
prestressed concrete

A Recent Development in Structural Elements

By Audun Ofjord

The basic idea of prestressed concrete is to eliminate the tensile stresses in the concrete by imposing compressive stresses in those portions of the concrete which would normally undergo tensile strains due to load.

The first patents on the system of prestressing were issued in 1888 to P. H. Jackson of San Francisco and to C. F. W. Doehring of Berlin, Germany. It is a peculiar coincidence that patents were issued at the same time at locations so far apart.



Courtesy of the Prestressed Concrete Co., Ltd., of London

A railroad tie of prestressed concrete.

In ordinary reinforced concrete the tensile forces are taken by the reinforcing steel, and in design procedures it is assumed that the concrete takes no tension. The concrete which is active in a concrete beam is thus only the concrete in the compression zone (above the neutral axis which is usually in the upper half of the beam). Most of the concrete is therefore just fill material to provide spacing between the compression zone and the tension steel.

In prestressed concrete the whole concrete section is active in compression while the steel in general carries only the applied prestress.

Before 1928 the idea of prestressing was tried out by engineers here and abroad, but with little or no success. The compressive stresses could be induced in the concrete but they could not be maintained indefinitely. It was in 1928 that the French engineer, Freyssinet, first realized that high-strength steel wire and first-class concrete were necessary to produce prestressed concrete. He explained the plastic deformations in concrete due to creep and shrinkage. He likewise pointed out that the use of high-strength steel would permit steel prestress values several times as great as stress losses which result from the above factors, thus providing high effective prestress after these inelastic concrete strains have occurred.

Prestressed concrete has some advantages over ordinary reinforced concrete. In the first place the resistance to cracking of the concrete is much greater, since even in the loaded prestressed element no tensile stresses occur. This is particularly advantageous in railroad or highway bridges. Secondly, the prestressed structure is much lighter than ordinary concrete structures. This enables one to have larger spans with smaller cross-sections. Thirdly, one saves on steel quantity in prestressed concrete by making full use of the high-strength steel wire employed.

Prestressed concrete does, however, represent certain disadvantages in its practical applications, as it is tedious and difficult to apply the prestress. However, quite a few methods have been developed and are still being developed to make the application of the prestress as easy as possible.

All the methods of prestressing may be classified into two groups:

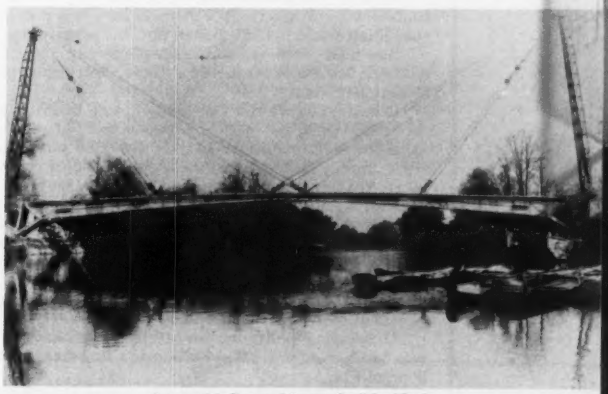
1. Pre-tensioning in which the wires are stretched before the concrete is placed, and
2. Post-tensioning in which the wires are stretched after the concrete has hardened.

Practically all methods of prestressing employ hydraulic jacks to produce the required prestress. The outstanding methods are those developed by Freyssinet (France) and Magnel (Belgium). Thermal stretching by electric heating has been tried in this country by Billner and Carlson. A new method of prestressing by post-tensioning has recently been developed in this country by K. Billner.

The methods of anchorage and stressing may be divided into three groups:

a. Stressing the steel by bearing on the concrete which has previously hardened.

(*Continued on page 32*)



Courtesy of the Prestressed Concrete Co., Ltd., of London

The Esbly Bridge over the Marne in France. It has a span of 245 feet and only three-foot depth at the crown.

the planner and society

Sensible Planning Makes the City a Better Place in Which to Live

By Peter D. Paul, '54

Did you ever notice a gnarled old tree with a thick trunk? Once it was a sapling. To grow, a tree continually adds layers onto the outside of its central layers. Often the inside dies; then the outer part must support the whole tree. A tree cannot replace a rotted core; it dies. But a city can replace its deadwood.

What is the core of a city like?

* * *

Rain fell, wetting the sidewalks and the streets, wetting the dirty concrete and the smooth asphalt. It hung in the misty air, gathering in drops and falling to the sidewalks, from rotten gables to the streets below. The steady relentless dripping of raindrops, drumming on the pavement, and the footfalls — dirty shoes trammelled the water into slime on the sooty pavement — honking of horns, and the hissing sounds the tires make on the wet pavement, factory whistles tooting, shop doors shutting, sounds of motors and brakes, traffic sounds, sounds of vendors screaming, of men and children walking on the damp sidewalk, dull, listless sounds all, they filled the air, fusing into the monotonous cadence of street noise.

Yellow lights shone on the pavement, and reflected in the water. It was dark, and myriad beams brightened the avenue. There were street lights and auto lights, lights of the windows of shops, from kitchens and hallways, lights from cigarettes, and from a thousand unsure sources, a perfunctory dissonance of street lights suggesting the tawdry ennuye boldness of city color.

Impersonal, repetitious, monotonous, this is the core of humdrum urban existence. Business here moves with a quick pulse. The city is a center of industry, and a crossroads of commerce. But its sociological pace is sluggish.

The city is just an overgrown town trying to accommodate a million people by the same methods its smaller counterparts would accommodate a thousand. The city is too large to serve as a community; it is too large for the people to encompass, and too large to encompass the individual.

The core of the city is an undesirable place to live. True, it is close to the heart of the city, . . . but it is rotting, a dying core of the growing city. Life is repetitious, a monotony of day after day tasks, the same harsh lines of houses day after day, the same neighbors you meet in the street and do not know. You live in the city; you work in the city. It becomes a part of you, and you become a functioning part of it.

You are a functioning; no more! You are an unimportant part of a giant after your work is done, a part of a mass, a body to feed. You buy your entertainment from the same stock that Mr. Jones buys his. Your only friends are those within your family, and a few casual acquaintances where you work. You are not a part of anything. You are not significant in your com-

This typical part of the core of a city is just like any other part of the core. This loosely connected community has no arbitrary boundaries, and is beyond the scope of any individual within it.

As merely a group of city blocks, it is not functional. Providing merely a place to live, it is poorly coordinated and not integrated into the community.

Business: scattered throughout, poorly placed, in ample buildings, business mediocre, does not serve community amply.

Industry: scattered throughout, not helpful to residential area, not part of community.

Roadways: connect center of city and outlying areas, merely pass through area, give it little service, create traffic difficulties, traffic hinders area.

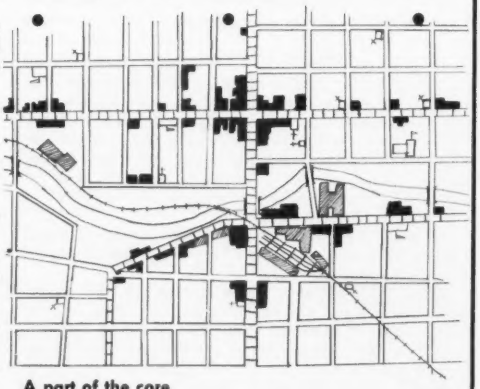
Parking: on-street, inconvenient, ties up traffic.

Public transportation: direct lines from center of city to outlying area also serve this area; service often slow, hindrance to traffic, inefficient, often inconvenient.

Recreation: little or no community facilities provided, unhealthy atmosphere for children.

Housing: repetitious, uninteresting, often substandard; residents take little pride in homes and community.

Educational facilities: schools scattered throughout area serve to take care of education, but serve little other purpose in community.



A part of the core.

Social atmosphere: *negative* — facilities to encourage a community way of life are noticeably lacking. The physical structure is indifferent to a sound society. The individual has little value. He is provided with a building in which to live, not a community in which to participate.

munity, because you do not live in an integrated community.

It is not necessarily a slum area, yet. The old houses were built for shelters, shelters for workers. Some slums have been cleared and new ones built. New slums? What is to prevent it? The area has no pride in itself; it has no heart, no purpose, but to rot.

Rows of bricks, and rows on top of rows, rows of bricks planted in concrete, sunk in a concrete earth. Is this a city? And do people count for nothing? Laugh, city! What would you do without them?

City, this is your deadwood. Who wants to live here? They cannot leave you; they will not. But they are trying to get to the outer rings. You must act!

They need the city; it nurtures them. It means jobs; it means commerce and prosperity. But they need more; they need vitality, a place in the community, a place in society. Will they support the city? Can the city continue to nurture them?

The deadwood must be replaced.

* * *

To remove this deadwood a great deal of foresight is needed. The social and physical structures must be interdependently investigated. Can some improved physical structure be utilized to better the sociological structure? How shall the city go about revitalizing itself? This is the job of the city planner.

* * *

The practice of city planning is not a new one. Centuries of mistakes have shown the desirability of planned cities.

But city planning as a science is a new concept. Scientific city planning is a necessity. It is the price of continual lack of planning and short-sighted planning of the past.

Today in planning, as in architecture, the configuration is function. The modern planner is not averse to the symmetry of his forerunners, but symmetry has become unimportant.

This change in emphasis was bound to come. The cores of most of our large cities were literally rotting. The industrial revolution had brought hundreds of thousands flocking to industrial centers. Where were these people to be put? Already outmoded and crowded housing was packed beyond all reasonable limits.

What happened? The blighted area is only the surface result; more important the cities were stratified, crystallized into class segments, cut into poorly co-ordinating parts. The individual suffered; society as a whole suffered. Dissatisfied suppressed masses are a blight upon any society.

The city planner's job is to re-create the city so that its physical structure is of the greatest possible use to its social structure. This is a large order.

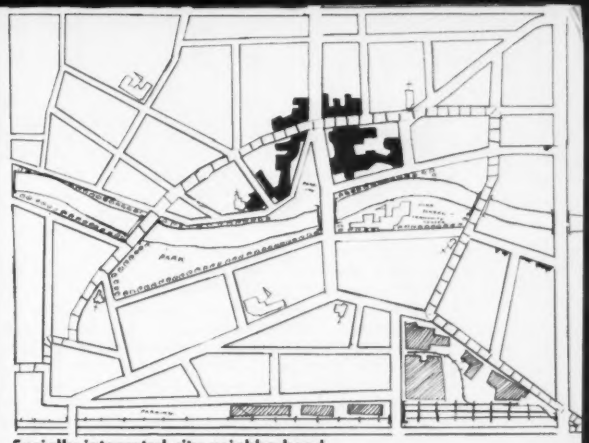
The most evident blight on the city is slum housing. Such a physical plant cannot be conducive to social health. Nowhere is class so strictly set as in group areas of the cities. Often groups of people of similar national and economic background are thrown together and packed into a tiny part of the city. Their common complaints are multiplied. Vertical social mobility from the slums becomes practically impossible without horizontal mobility from the slum area.

At the opposite pole from the slum is the highly segregated, upper-class suburbs. Here the physical structure is at its best. Such units may be found around any city.

The social structure of the city is a complex one. Where hundreds of thousands of people from all walks of life are thrown together, it cannot be otherwise. Most people live between the top and the bottom of the social scales. With these people lie many of the problems arising from the complexities of urban living.

It is not the planner's job to build houses; he must

(*Continued on page 26*)



Socially integrated city-neighborhood.

By integrating the area socially other problems are eliminated. Here the same area shown in the other diagram has been redeveloped into a city-neighborhood. Arterial highways surrounding it tend to form arbitrary boundaries.

This city-neighborhood is functional; it serves as a community in which the individual has an important place. The community is centered to bind the people together. It provides more than a place to live; there is a healthy social structure. The neighborhood is planned and coordinated.

Business: located at center of community, helps to bind it together; business amply housed, serves people, is more prosperous.

Industry: has a part in complete neighborhood scheme, located so as not to blight housing, provides jobs for some in community.

Roads: arterial roads by-pass center of community, provide faster, more convenient transportation for everyone; roads within community planned to serve community; large blocks, dead-end streets common.

Public transportation: rapid underground transit from city center serving outlying areas, connecting with shuttle bus to serve community throughout; frequent, efficient service.

Recreation: recreation areas, playgrounds, parks, provided; off-street facilities for children within each block; community centers publicly provided.

Housing: standard at least, above standard as often as possible; imaginative, functional houses in which the individual can take pride, inexpensive apartment facilities available to meet demand.

Educational facilities: conveniently located, serve community; emphasis on better than required minimum.

Parking: off-street, convenient to shopping areas, does not hinder traffic movement, on-street parking in areas of light traffic.

Social atmosphere: *positive*—designed to give the individual a sense of community pride, a sense of belonging to something; convenient copious facilities encourage him to participate in the community and become a part of it.

the brain

By W. Norbert

The brain is a funny organ. It controls all the sensations of the body and yet it can be touched and cut with no local sensation at all. One man will die of a slight concussion and another can have a crowbar shot through his head with nothing but a ruined disposition to show for it. Recently it has become fashionable to do all sorts of weird things to the brain with needles and hot wires in order to cure or relieve some of the many forms of depressive insanity. It's an ugly business — I don't like it. Sometimes it cuts out a man's conscience, and pretty nearly every time it does eerie things to his judgment and personal balance.

There was a fellow in Chicago, for instance, a big-shot salesman with an insurance company. The only trouble with him was that he had the blues so bad that they never knew whether he would leave for home via the elevator or the tenth-story window. His company

begged him to have a little piece of his prefrontal lobe out, and he consented. After that, Mr. Big-shot became Mr. Bigger-shot. As a matter of fact, he outsold every salesman in the history of the company. As a token of their regard, they made him vice-president. They forgot one thing, however, that a man with a prefrontal lobotomy isn't very good at following the pea under the walnut shell. When he got out of the selling game into Higher Finance, he went flat and so did the company. No, I shouldn't like to have anyone tamper with my inner wiring diagrams.

This brings me to a case which came to my attention the other day. I belong to a small group of scientists which meets once a month in the private room of a little restaurant. We have a scientific paper to give an excuse for our meeting, but the real reason for it is a miscellaneous interest and an unbridled loquacity on the part of the whole gang. It's no place for the striped pants boys. We rib one another unmercifully; and if you can't take it, the door is always open. I myself am something in between a mathematician and an engineer, but perhaps the bulk of us are medical men. Heaven help the waitresses when the medical boys get talking freely! I won't go so far as to assert that the electric lights go blue, and that the atmosphere smells of sulphur at times, but that is the general idea.

Waterman is in our good graces. He runs a state madhouse some fifty miles away, and looks like the amiable and prosperous proprietor of a delicatessen shop. He is short, fat, walrus-moustached and completely without vanity. He usually has a lame duck in tow. This time he came in with a rather tall, sallow man, whose name I didn't get. I did get the impression that he was a doctor, but he had some of the curious hesitation in company that I have seen in prospectors or engineers who have been too long away from normal civilization, confined in the mountains of Korea or the backwoods of Borneo. It is a mixture of lost familiarity with civilization and overdeveloped self-consciousness and self-criticism. Some of those boys had had to do things that no civilized man can do with impunity to himself, and they carry around the marks ever after.

I do not know how the conversation got around to frontal lobotomy. I think one of the engineering guests asked about it as a possibility for a distant relative who was a mental patient. Everybody present had an opinion about it. A few of them spoke for it, but most of them — even the brain surgeons — did not want any part of it.

Then we got talking about what a modern automobile accident can do to a child's brain. The discussion was not exactly dainty, even as doctors' discussions go. The talk was going hot and heavy; and I do not think anyone noticed anyone but the fellow he was talking to. Suddenly there was a little crash. We looked around to see Waterman's friend cold out on the floor. His forehead was covered with beads of sweat. Waterman knelt down beside him and felt his pulse.

"I don't think it's anything serious," he said. "He is a patient of mine, but very intelligent, and I thought it might cheer him up a bit to come along. He is suffering from amnesia, and we don't know his real name. I shouldn't have taken the chance of bringing him here. Come on, let's carry him out. It won't be necessary to break up the meeting."

Waterman telephoned to his hospital for an ambulance, while two or three of our medical contingent got in touch with the proprietor of the restaurant. He was flustered, but told us to carry the unconscious man to a couch in a back room. Our patient was beginning to come to a bit. He was in an obvious state of emotional excitement and confusion. He kept talking incoherently. Among the words that came out were "gangster," "Little Paul," "Martha," and "the crash." The words formed sentences, but they were spoken too low for us to understand them.

Waterman fetched his bag up from the cloakroom. He administered some sedative; a barbiturate, I think. For a while, it quieted our man; but you never can tell about these sedatives. After a while the patient opened his eyes. His mutterings became louder and more intelligible. The words were fairly coherent.

Waterman is a good enough doctor to use opportunities when he finds them.

"This is my chance," he said. "He's on a talking jag. Some six weeks ago a cop picked him up in a doorway. The police turned him over to us. He doesn't even remember his name. We know that he has been a doctor, and it isn't hard to see that he has been through

some pretty times. Up to now he's been getting back strength, and we haven't wanted to disturb his recovery by questioning him too much. However, since we seem to have got him into a talkative mood, here goes!"

The return of the banished memory was fascinating to watch. Waterman is a smooth worker, and it was a delight to hear him ask questions. The new personality emerged like the face of a drowned man when they bring him to the surface with grappling irons. I haven't kept any record of what I saw; but Waterman was writing steadily in a little black notebook. The following conversation is a transcription of his record.

Q. "What is your name?"

A. "My name is Arthur Cole."

Q. "You are a doctor, aren't you?"

A. "I am."

Q. "What medical school did you go to?"

A. "Central Western Medical, in Chicago. Class of 1926."

Q. "Where did you pass your internship?"

A. "I was surgical intern at the Physicians and Surgeons Charity Hospital in Chicago. You know where the hospital is — down at the South End."

I dimly remember the Physicians' and Surgeons' Charity Hospital in Chicago. It was a dingy pile of greasy red brick in that festering hell of dead streets where the South End meets the West End.

Q. "Surgical intern. That's interesting — did you go in for any special branch of surgery?"

A. "Yes, of course, for two years I took pretty much what they gave me, but I always wanted to be a brain surgeon. What was I saying? I'm afraid I am very confused. I had forgotten altogether that I had been a brain surgeon."

Q. "Oh, so you were a brain surgeon. What did you do after your internship?"

A. "I remember a long line of locked corridors and barbed windows. What was it called? It must have been a hospital for the insane. Oh yes, now I recollect. The Mere — Mere — Meredith County Hospital for the insane. That's in Illinois isn't it?"

Q. "I think it is. Do you remember what they called the town?"

A. "Buckminster. No, it wasn't Buckminster. Now, I have it, it was Leominster."

Q. "Yes, that's right, it is at Leominster. How old were you when you went there?"

A. "About thirty."

Q. "Do you remember the year?"

A. "It was in 1931."

Q. "Did you go there alone?"

A. "I went there with my wife. I am married, aren't I? What happened to my wife? She's here, isn't she? Oh, my God! Martha — Martha."

His voice rose to an incoherent scream. Waterman said, "I'm afraid we shall have to try some more sedative. I'm going to make the dose as light as I can. I don't want to lose this opportunity to find out more about him."

The excitement of the patient gradually subsided as the drug took hold. For a few minutes he seemed too dazed to say anything. Then the confusion began to wear off and Waterman recommenced his inquiries.

Q. "You must help us if we are to help you," he said. "Pull yourself together. How long had you been married when you went to Leominster?"

A. "Not two years. Martha was a nurse at the Chicago Charity Hospital. Martha Sorenson was her name. She came from Minnesota, I remember. Her father owned a wheat farm somewhere near the North Dakota line. We went back there to be married."

Q. "Any children?"

A. "Yes, a boy — Paul. Now it all comes back to me."

He sunk his head in his arms and began to weep. He burst into incoherent cries. "Where is Paul? Where is Paul?" It seemed indecent to be the witness of such pain.

Waterman stood by the head of the couch where Cole lay. I had always thought of him as the life of the party — gay, witty and salty. I had never seen Waterman, the doctor. He was quiet and dignified, and his voice was more soothing than any anodyne. He was Aesculapius himself, the God of Healing.

Q. "Calm yourself, Dr. Cole," he said. "We want to help you, but you are the only man who can teach us how to. Tell us something about the County Hospital. Did you live in?"

A. "For a few months. Then we took an old farmhouse about a mile away. Martha thought we could fix it up, but I didn't see how we could ever dig through that mess of trash and dirt. Martha could make even

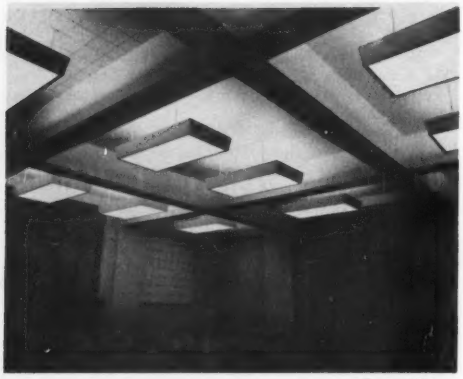
Cole found the Brain's head wrapped in a clean towel, a line of dried blood coming from his left nostril.

a pigsty liveable. Let's see: I remember there was a U. S. highway passing in front of the house."

He sank onto his face, his head between his arms — his shoulders heaved. "The brakes," he said. "I can hear them scream. The crash! The car turned over. Blood on the road — blood on the road! I could see it and I couldn't do a thing."

Waterman motioned to us to be quiet. I felt the

(*Continued on page 33*)



Raymond Ghosn

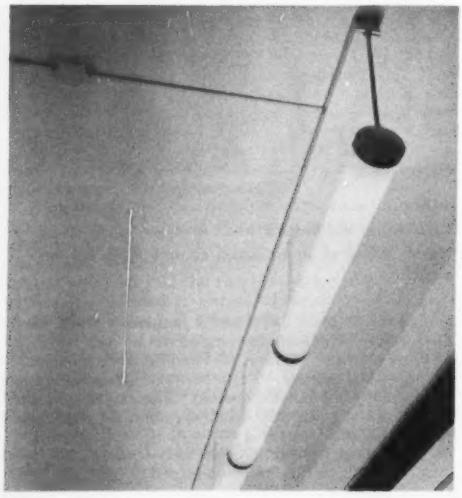
So-called "landing barge" fixtures in Room 2–190 where deep beams made other installations difficult.

Once it was thought that a room could be lighted adequately by pouring in enough footcandles to give a high lightmeter reading at the working surfaces. Today, as a result of physiological and psychological research, an entirely new set of principles governs the design of lighting systems. We know that in order to satisfy the complex human requirements of seeing without undue strain, the entire working environment must be considered. Walls, ceiling, floor, furniture are just as important as the lighting source itself.

An adequate quantity of light is still a necessary but not a sufficient condition for visual efficiency. To complete the picture we must avoid all excessive contrasts in the brightness of surfaces in the visual field.

MIT Lighting Committee's own luminaire design has been installed in many offices and drafting rooms.

Raymond Ghosn



Brightness in a room may be produced in three ways: by the light source itself, by light diffused through some translucent medium or by light reflected from any surface in the room. Any exposed light source of the conventional type (incandescent or fluorescent lamp) acts like a point source and would have a brightness far exceeding that of all other surfaces. For instance, an exposed fluorescent lamp is about fifty times as bright as its immediate surroundings.

Experiments have shown that people suffer physical and psychological discomfort when the brightness ratio exceeds ten to one. For ideal conditions in rooms where the visual task is severe (i.e., drafting rooms, offices, classrooms) the Illumination Engineering Society recommends a ratio of three to one in brightness (helios). This would mean that the brightest part of the room should be only three times as bright as the work and the work not more than three times as bright as the darkest area, thus eliminating glare and objectionable shadows.

Obviously to obtain these low ratios we will have to do two things: (1) lower the brightness of our light source (maintaining the required illumination level), and (2), raise the brightness of the reflecting surface.

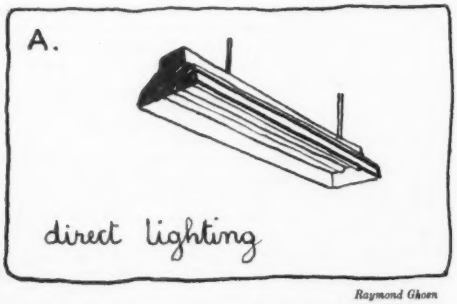
From Point Source

By Raymond Ghosn

I. The Lighting Source

Lighting is obtained through the use of luminaires (commonly called fixtures) which include the bulb and any kind of reflector or diffuser controlling the distribution of light from the source.

The new concern with comparative brightness in rooms used for intense visual work gives a clear set of



Raymond Ghosn

criteria for the selection of luminaires. As before, luminaires must provide: (*a*) enough light on horizontal surfaces, (*b*) high enough level of illumination on vertical surfaces, (*c*) elimination of direct glare (high brightness contrast) from a source in the visual field much brighter from its surroundings, (*d*) elimination of glare from a reflected image of an excessively bright source which may occur on or near the working surface, (*e*) low maintenance cost resulting from ease of cleaning collected dust, (*f*) even distribution of brightness throughout the room, (*g*) initial cost.

With these criteria in mind we may now examine

the kinds of luminaires which have developed through the years.

1. Direct lighting is most commonly used and consists of the familiar exposed lamp with enameled reflector above. In this system, all the light is beamed downward leaving a dark ceiling. Against this dark background the brightness of the source itself creates the greatest glare.

2. Semi-direct lighting makes use of some diffusing element such as frosted glass or louvers to lessen the brightness of the source by increasing the surface from which the light may be radiated. Reflected glare is not reduced by the louvered diffusers, however, as an image of the lamp is easily transmitted to the eye by any reflective surface in the plane of work.

When semi-direct lighting fixtures that have opaque sides are ceiling-mounted, they project most of the light downward, and create objectionable contrasts by leaving dark areas around the bright fixture in the ceiling. When they are suspended from the ceiling, with semi-concentrating reflectors slotted at the top to allow some of the light to escape upward toward the ceiling, sharp contrast between the bright fixture and the ceiling background is reduced considerably.

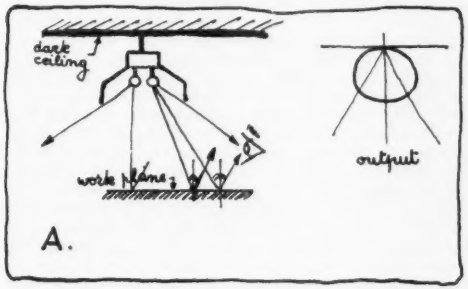
to Luminous Ceiling

and Bernard Spring, G.

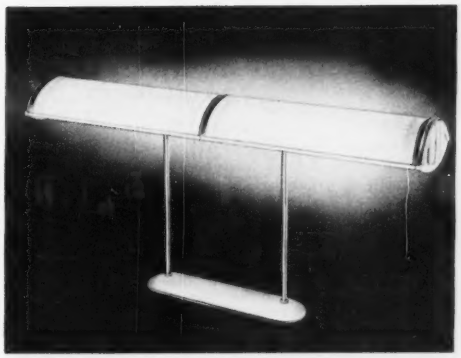
The depreciation of enclosed ceiling-mounted fixtures depends on the tightness of the joints. Open-bottom fixtures and fixtures with louvered bottoms are conducive to good maintenance. Open-top and closed-bottom suspended luminaires facilitate collection of dust and require a regular maintenance schedule to insure continuous good output.

3. Indirect lighting provides light only by reflection from walls or ceiling, with the source itself being masked. The shield used to block off the source always creates a dark patch next to what might well be a very pleasant radiating area of low intensity illumination. In addition, the material that shields the lamp and reflects the light toward the wall or ceiling is a perfect dust catcher and must very frequently be cleaned to produce consistent good results.

4. Semi-indirect luminaires throw most of their light upward toward a highly reflective ceiling and a smaller portion downward through some diffusing material.



Raymond Ghorn



Raymond Ghorn

A commercial luminaire, the Wakefield Star provides good illumination as installed in the new 12 MEV laboratory.

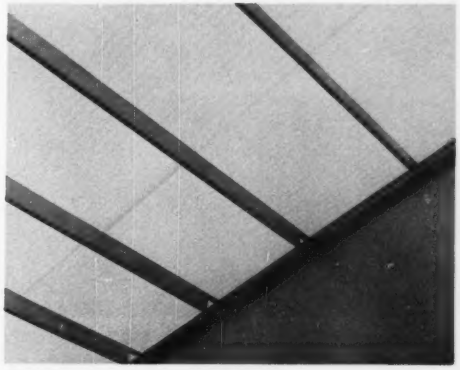
These fixtures can produce lighting with very favorable low brightness contrasts because their main output is radiated from a large area at low brightness and because enough light filters through the bottom to make the source itself have the same low brightness as the ceiling. Again, louvered-bottom diffusers will permit glare by specular reflection of the lamps behind them, but offer the advantage of being easier to maintain than a dust catching sheet of frosted glass or plastic. Besides the difficulty of maintaining dust-free performance, this type of fixture often suffers from having opaque sides which create dark bands in the otherwise even glow of light. Both these problems have been solved by making a semi-indirect luminaire which is cylindrical. The use of this type at M. I. T. will be discussed later.

5. *Luminous ceiling.* — The problems associated with semi-direct lighting can be eliminated by spreading a source of low intensity over the entire ceiling of a room and shielding it with a diffusing screen. Serious reflections have marred many luminous ceiling installations which used louvers or fins as a diffusing screen.

(*Continued on page 30*)

Luminous ceiling as installed in Room 2–143. Perforated metal fins contain sound-absorbing pads.

Raymond Ghorn



x-ray diffraction

A Powerful Tool in Science and Industry

By Sewell P. Champe, '54

Compared to the medical use of x-rays their application as an instrument of research in pure science is relatively obscure. Yet since 1912 the work in this field has been so extensive that it constitutes a whole new branch of physics. But why does x-ray diffraction warrant such intensive investigation considering how narrow a field it is compared to the rest of physics? The answer to this lies in the reason for the discovery of this phenomenon.

From the time of the discovery of x-rays in 1895 by Conrad Röntgen and up until 1912 very little had been found out about the nature of this mysterious radiation. All of the information that had been accumulated in seventeen years led only to the belief that they were electromagnetic in nature and had a wave length of about 10^{-9} centimeters. On the other hand, since 1850 it had been known that the atoms of a crystal were so arranged that the spacing between atoms was of the order of 10^{-8} centimeters. But it took seventeen years for these two bits of information to come simultaneously into the mind of a theoretical physicist named Laué who first suggested the idea that crystals might be used as a diffraction grating for x-rays. Upon this suggestion investigations were carried out by two experimental physicists named Friedrich and Knipping, and indeed a diffraction pattern of the type predicted by Laué was observed.

Laué immediately recognized this new discovery as an immensely powerful instrument not only for the study of the nature of radiation but of the basic units of matter. That is why the instrument of x-ray diffraction is so important; it provides a probe, or if you will, a new kind of light by which we can peer into the invisible world of the atoms and molecules. The methods of analysis used in x-ray diffraction are analogous to shooting a machine gun through a very narrow-spaced, iron, picket fence, then determining the architectural design of the fence, the nature of the stream of bullets, and perhaps something about the gun by observing where the bullets glance and at what angle they strike the fence.

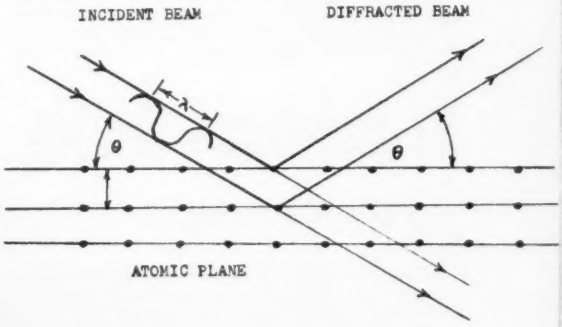


Fig. 1. This drawing shows how a beam of x-rays acts when it strikes an atomic plane of a crystal.

Fig. 2. A Laue photograph of an NaCl crystal using continuous radiation.

Perhaps before going into the author's experiments in x-ray diffraction it would be advantageous to review just what the mechanics of diffraction are. The phenomenon of x-ray diffraction is based on the following facts: When very short, electromagnetic waves are propagated through thin sections of matter, the atoms of which are arranged periodically as in a crystal, parts of the beam will be scattered in various directions; these directions depend primarily on the arrangement of the atoms of the substance under observation, the wave length of the x-rays, and the angle at which the beam is incident upon the plane of the crystal that is doing the scattering. If the reader is interested in precisely how these facts are mathematically related, he is referred to W. T. Sproull, *X-Rays in Practice*. The reader who is familiar with the electromagnetic theory of radiation will realize that the machine gun analogy is not exactly correct. When the scattering of continuous x-rays is photographed the pattern is an aggregate of spots called Laué spots. These spots are not as one would like to think due to a simple bouncing

of the x-rays from an atomic plane; rather they are due to the constructive interference of two parts of a reflected beam. Referring to Figure 1a, we have a parallel beam of x-rays encountering two planes of a crystal. If a particular wave front strikes an atom of the first plane, part of it is reflected in a certain direction; the remaining part of that same wave front continues to an atom of the second plane and is likewise reflected in the same direction. Constructive interference of the two scattered parts of the original wave is observed only when the equation

$$n\lambda = 2d \sin\theta$$

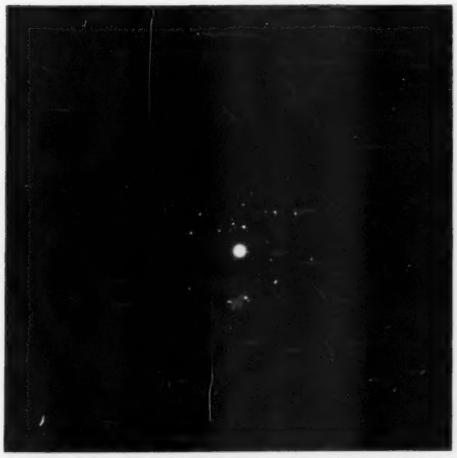


Fig. 3. This Laué photograph of $CuSO_4 \cdot 5H_2O$ indicates periodic structure.

is satisfied, where λ is the wave length of the x-rays, n is an integer, d is the distance between the atomic planes of the crystal, and θ is the angle of incidence. This relationship is known as Bragg's Law. It is to be noted that actually scattering takes place at all angles and for all wave lengths, but at only the particular angle and wave length designated by the above equation is constructive interference, and consequently any reflected beam, observed; all of the other scattered rays are canceled because they are out of phase.

The distinction should be made here between continuous and characteristic x-rays. A beam of general radiation from an x-ray tube consists of x-rays of all wave lengths in the range of 10^{-7} to 10^{-9} centimeters; this is called continuous radiation. However, at one particular voltage of the x-ray tube the beam contains x-rays of only one wave length; this wave is characteristic of the target metal of the tube, and the radiation is termed characteristic or monochromatic. When continuous x-rays are used the diffraction pattern is an aggregate of spots, but when characteristic rays are employed the pattern is usually in the form of rings or lines.

This explanation is by lack of space somewhat meager, but it will perhaps aid in familiarizing the reader with what is meant by a diffraction pattern which is simply the photographic record of these scattered waves which reinforce each other.

Description of author's experiments: In order to perform experiments in x-ray diffraction I, of course, had to have a suitable source of radiation. This involves more than it sounds and was actually the most difficult part of the entire experiment, since I had no previous knowledge of high voltage techniques or protection from radiation. The source of radiation I used was a Coolidge x-ray tube, which is actually just a high-voltage, two-element rectifier containing a heavy tungsten plate for an anode. To this tube is connected the filament and high-voltage leads just as in any rectifier. However, the voltage used is of the order of fifty thousand volts and must be extremely well insulated. This presented one of the major problems since the high-voltage wires must pass through a lead box in which the tube is enclosed. Of course, suitable shock-proof cables are available for the transmission of high voltages but after investing in an x-ray tube, transformer, and one hundred pounds of lead I found the cables too expensive for my purposes. I succeeded, however, in providing suitable insulation by use of auto ignition cable enclosed in two thicknesses of rubber tubing and passed the cables into the lead box by means of large porcelain bushings. As a word of caution to anyone contemplating x-ray work: I would advise staying completely away from homemade equipment when it is in operation. A slight contact with a cable having weak insulation will almost inevitably transport the researcher into another world. Also if improvised lead shields are used for radiation protection I would suggest that the experimenter arrange for some means of remote control of the apparatus and be one hundred feet from the source of radiation. Small doses of x-rays are not considered harmful; but exposures of diffraction photographs take from thirty minutes to several hours and suitable protection is absolutely necessary. If fluoroscopic work is planned, commercial machines should be used which are comparatively safe.

The length of exposure presents another major problem in some types of diffraction work because the anode of the tube becomes extremely hot after several minutes of operation. In commercial equipment the problem is solved by use of an elaborate water cooling

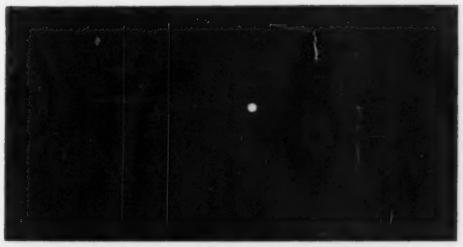


Fig. 4. Absence of pattern in this photograph shows lack of definite structure in $CuSO_4$.

system inside the tube, but the method I used was to make a number of short exposures with an interval for tube cooling.

The diffraction camera can be a very complicated piece of apparatus or very simple, the type depending on the purpose. Some cameras provide temperature control, crystal rotation, film rotation, and control of other variable conditions. The type I used was a simple Laué camera. The essential part of the camera is the collimator tube which provides the very narrow, parallel beam of x-rays needed. The apertures of this tube are usually a fraction of a millimeter in diameter. For x-rays to pass through the collimator tube the holes

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the graduate engineer in industry

M. I. T.'s Mechanical Engineering Cooperative Program in Operation

By Karel den Tex and Lee Rohde, '51

Imagine yourself a year or so from now applying for your first job. You stride into the employment office feeling confident that all the years of knowledge you have accumulated are just what this company needs. Under your arm you carry documentary proof of your scholastic standing, the courses you took, your athletic prowess, and, of course, a fine character reference from your minister. Just to leave no doubt in the mind of the receptionist you introduce yourself proudly: "I am Joe Graduate. I have a Bachelor of Science degree from Boola-Boola College and I wish to see the General Manager about a position."

Lee Rohde, '51, and Finley Snyder, Production Inspector, at work in the Production Inspection Department.

Hours later it is your turn to be interviewed, not by the General Manager, but by someone in the Personnel Department. He looks over the application blank you have filled out and asks you about your background. Somehow he doesn't ask to see any more of your scholastic record than your cumulative grade. He talks about your living habits, how you got along with your roommates and professors and other subjects you had not expected to be questioned on. You tell him in answer to his questions about previous jobs and knowledge of industry, about your job in a drug store and the courses in production and personnel administration.

"I see you have no experience at all in this kind of work, Joe, and that you don't really know what you want to do. We have had to turn away many graduates like you who have only a degree and limited experience to offer. Thank you for dropping in, and we will let you know if anything comes up."

There are a few obvious mistakes you made in preparing for your interview, and there are some things that you slipped up on which are not so obvious, at least not to the average student. Perhaps, after they have been pointed out to you, you will agree, and find an opportunity to do something about them before looking for your first job.

This discussion will stress the value of getting experience in the type of work that you are training for before you actually start on your first job. There are at least three noteworthy advantages in gaining perspective of the engineering field. You choose to select your options and electives to meet a goal which you had not previously known about. The second advantage was made evident by the example of how your failure to distinguish yourself from other graduates, and your failure to demonstrate any knowledge of your future work can make you unimpressive to the employer. You will realize the third advantage when after you are employed you find that you have little or no time to become familiar with the functions of the other departments, and, therefore, you are unknowingly handicapped in your work if you have not had an opportunity to study such an organization before.

In a six months cooperative course at the Fairchild Engines Division of the Fairchild Engine and Airplane Corporation that was organized through the mutual efforts of M. I. T. and Ranger, the training program being offered is quite unique among programs of its sort, as will be pointed out later on, which is facilitated by the relatively small size of the Fairchild Engine Division. Also, the work being done is almost exclusively on government contracts, so that one misses some of the characteristics of commercial industries. The organizational structure of the company is quite conventional, however, in the engineering field and its size allows the trainee to grasp the interrelation of the departments easily. Most of the impressions given here are the result of direct association with the departments, a privilege very few regular employees ever get.

Although every student thinks he is preparing himself for his future job, very few know what the job is going to be and what it calls for. This is not surprising when one sees how little is done in the schools to acquaint him with this aspect of his studies. He has probably never realized what the average employment office is looking for. So let us start right here and find out what qualifications they seek in their engineers.

Thanks to the requirements of degrees issued by different institutions, there is little variation in the education of those who have been granted the same diploma. Resumés itemizing the educational background in detail are only a waste of time to the applicant. Much more important are factors that have shaped the applicant's personality and have broadened his knowledge. Hobbies reflect his interest in fields outside of his work, part-time jobs can indicate the responsibility demonstrated to support the person or his family and his ability to pitch in and tackle a problem. Character references are usually of small interest except for the reflection on the type of people one associates with. Personal appearance can be exaggerated for it only is held against him if it is going to be detrimental to the position he will occupy. The applicant should be completely frank. Exaggerated and overly complimentary resumés designed to convey a false impression will soon be revealed because interviewing is now being done more and more by methods estab-

Lee Rohde, '51, and Karel den Tex, '51, assist in the test of an experimental engine.

lished on psychological principles. An honest statement of one's status and one's intentions, ambitions and abilities will receive the corresponding recognition and appreciation.

More often than not the applicant will apply for a job that he is not qualified for and that he does not understand. He may state that he wants to get into design or sales work, little realizing that to rise to these positions, years of training are required in more primary positions. Most companies will place their new graduate employees in one or two departments where they will receive the basic training they will need to handle higher positions. In the engine industry the two departments usually chosen are Drafting and Test Engineering. These can be considered ultimate objectives in themselves, of course, and many engineers will remain in this work. But for those aspiring to enter the other departments such as Design, Development, Stress Analysis, Sales, Field Engineering, and some phases of production, the experience and training that can be gained in Drafting and Test Engineering is prerequisite. If you belong to the small percentage of those entering the Drafting Department that have an engineering degree you will probably expect to advance to the Design Department. About three years of drafting experience will allow you to get into product or test equipment design. You will soon find out the importance of a broad knowledge of machine shop practices before attempting drafting or design work. Without an understanding of production processes you will find it difficult to meet design requirements and still incorporate economical machinery methods. The drafting work may appear quite elementary, but the significance of the drawing in all future phases of development and production is not to be underestimated. Unless the drawing is based on sound economic and functional engineering principles, all future work based on the authority of the drawing will be inferior. The work in Drafting Department will teach the engineer how to incorporate such sound judgment into his drawing, and how to present the configuration of the part clearly and concisely on paper so that no misinterpretation is possible.

Starting as a detailer you receive the reference for your drawing from the Design Department in the form of a layout drawing. This drawing will represent the designer's concept of an assembly or part in semi-finished form. Material specifications and approximate dimensions are indicated on the layout. Each individual part of the assembly is then drawn up in detail by the draftsman. Special consideration is given to such factors as tolerance, concentricity, surface finish, drill and tap notes, surface and heat treatment. The dimensioning must be coordinated with all mating and associated parts to insure proper interrelation of the parts. Finally an assembly drawing is made to indicate their relative position for assembly purposes.

As you become proficient at drawing and understand more about the art of detailing you become eligible for responsibilities of advanced detailing work and can ultimately become a checker. In this position you will criticize the soundness of detailer's interpretation of the layout, his presentation and clarity, and discover all mistakes and omissions on the drawing. A year of this experience will make you eligible for promotion to the Engineering Design Department as a junior layout man or as a junior tool designer if you chose that field.

A cooperative course cannot hope to make you a skilled draftsman in such a short time, but it can give you enough of an idea of the factors involved so that you feel you understand the nature of the work should you decide to prepare for a position in Design or decide to follow another phase of engineering.

Students with advanced degrees are qualified to enter the stress analysis section of the Design Department. This work will strike you as being very similar to what you are doing right here at school in your dynamics, strength of materials, thermodynamics, fluid mechanics and stress analysis courses. The theoretical work is quite isolated from the other functions of the company so that the newcomer can adapt himself quickly. He is also not so concerned with the drafting and production experience that a designer requires.

Karel den Tex learns the techniques of X-ray inspection from Robert McKie, Chief X-ray Technician, and Mr. Briggs.

The Metallurgy Department is similar to the stress analysis group in this respect, because here also the work does not require as much knowledge of the company organization and operation. What you would learn here beyond what you learned in college is primarily the application of theory to various problems. The cooperative course will help you much if you have already decided to enter this work. But if you have not decided this, you will benefit greatly by seeing how

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tech engineering news

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from the editor's notebook

Wait, as you must, for the springtime, to see and feel nature in the air. You remember, I suppose, the trees budding in the Fenway, the new green of the Great Court, the cheeriness of the Charles on a warm crew-day — and most of all the Esplanade, somnolent under the early summer heavens. Alas, the Esplanade is no more at all, and indeed the gladness of spring seems very far away. But I ask you to awaken to the spirit of the season, and to discover if you can, beauty in the grey skies of winter and in the hibernating world beneath.

Have you ever gazed for a time from an upper classroom at the Charles in a twinkling sunlight? Hugging its edge over in Boston are the red-brick dwellings of Beacon Street. Stretching into a broad panorama they are distinguished only by their jutting quaint chimneys. And one sees them to the left climbing Beacon Hill, capped by the gilt dome of the Old State House. Dickensian London — or Boston?

Have you ever stopped in the dead center of the Great Court, to ponder its expanse and strength? The Great Court is truly a seasonless monument. It is like a sphinx, cold and powerful, and yet the work of men. The weather or the sun cannot circumscribe its power.

Have you ever walked the length of Commonwealth Avenue when the snow is on the ground? There if anywhere is a world of bare tree-limbs silhouetted against snowy roofs and the warm light of many hearths. There is traffic, of course, but the scene is silent. Except for the crunching of your shoes on the snow.

Have you ever strolled the narrow streets on the back of Beacon Hill on a somber day or frostbitten night? The houses are thin and in close rows; the streetlights are relics of the gaslight era; and if perchance you espy a narrow portal into a little courtyard, and a man coming out with a coal hod on his back, you will wait expectantly for Scrooge himself to pop out of a tiny, high window and cry down to an urchin to fetch him the biggest Christmas turkey ever!

Have you ever paused before the great, curtained windows of the new library to look upon a city at dusk? About five o'clock (or earlier now, with the setting sun) one peers out of warmth and light into a cold and retiring world. The drawn-out hours of a summer evening are but a memory; everyone makes haste to his cozy rooms and thus the city seems asleep.

Have you ever walked briskly on a Sunday morn through Cambridge's Brattle Street? It is a region of old, comfortable homes and towering elms. The elms are shady and tall in the summer, and just as graceful and natural against a wintry sky.

Step out one day, and see for yourself.

G. B. F.

Our Authors...

W. Norbert is a variation on a very familiar name about the Institute. Once more Mr. Norbert has demonstrated his tremendous versatility. **Sewell Champe** hails from Montgomery, West Virginia. He won a First Prize for his X-ray apparatus at an exhibition of the West Virginia Academy of Science. **Audun Ofjord** came here from Norway in 1946; he graduated from Case Institute and is now a research assistant in the Civil Engineering Department. **Ray Ghosn** is a recent graduate from Architecture, and **Bernard Spring** is a graduate student in Course IV. Each is a former contributor; this article is their first cooperative effort. **Ed Leonard** is quite a busy man about the campus, but he has a nose for reporting and found a good story way up on the fourth floor of Building 3. **Professor Hurley** of the Geology Department was very kind to tell us about the continents; his writing services are in demand by others. **Lee Rohde** and **Karel den Tex** were eye-witnesses to the Course II Co-op Program — they spent a term at the Fairchild Engine Division of the Fairchild Engine and Airplane Corporation.

briefing the news

Savings in Plating...

It has long been almost an axiom in the metal-finishing industry that the brightness of an electroplated object can be no greater than that of the metal on which the deposit was applied. Since the bright appearance of the electroplated ware is often the basis of its customer appeal, a great deal of skilled labor has been required to obtain the desired appearance through polishing and buffing of the object prior to plating, or by performing the same operations on a deposit which lacks the coveted bright finish when it emerges from the plating bath.

Recent work has proven that plating can be conducted in such a fashion as to improve greatly the quality of the surface of a work piece during the plating operation itself. It is thus possible to eliminate all or a major part of the expensive polishing and buffing operations which have always contributed so heavily to the cost of electroplating for decorative purposes.

From the scientific standpoint it was brought out during the session that the older ideas concerning throwing power and metal distribution are hopelessly inadequate to explain such remarkable effects as those reported by C. E. Reinhard of the New Jersey Zinc Company in his paper on micro-throwing power. He showed how small surface defects are filled with metal during some plating operations in a manner that defies explanation by known scientific principles and theories. The improvement in the quality of surface which results from such plating is important, not only in the more economical production of better-quality plated ware but it offers a real challenge to those who wish to advance the science of plating through the study of the fundamental scientific principles governing the process.

Almost Invisible Drills...

Drills so small that it takes twenty-power binoculars to watch them at work are opening new possibilities in the production of all kinds of consumer goods, according to J. A. Cupler, II, General Manager, National Jet Company, Cumberland, Md. Cupler said that the manufacture and use of such drills has already reached the point where millions of minute holes are drilled with them every month in some industries.

The "micro-drills" are capable of producing holes as small as about one-thousandth of an inch in diameter. Among the many uses found for such holes is the drilling of minute dies for squeezing synthetic silk materials into fine synthetic threads. The accurately made steel drills used for such holes are far thinner than a human hair and operate under pressure so light the operator can hardly feel it. Nozzles of fuel injection engines also require extremely small holes. The first major application of micro-drilled holes in the medical field is the new "hypo-spray" for hypodermic injections. The drills are also expected to help United States watch industry compete better with the Swiss.

Uncommon Use for Rice...

If it were possible to write a recipe for making automobiles, many of the materials used would be familiar to any cook and housekeeper.

Salt, soap, sugar, iodine and even walnut shells are a few examples.

Now an automotive use has been found for one of the common staples in a kitchen cupboard — ordinary rice.

Rice is the basis for a unique method of cleaning carbon deposits from the combustion chambers of high compression engines without removing the cylinder head.

An automotive engineer made the discovery and his company developed it into a highly useful piece of service equipment. The device utilizes rice under air pressure to blast carbon from combustion chambers through the spark plug openings.

About half a pound of rice is consumed in cleaning an engine. Blasted into each chamber through a nozzle, the hard rice grains chip off the carbon crust and clean all surfaces. Rice and carbon are removed from the clean combustion chambers by adjusting an air control valve on the blaster.

statistics and machinery

(*Continued from page 10*)

directory, alphabetic and class lists, and other information now under consideration in the Registrar's and Admissions office. In addition to straight listing and accounting, certain mathematical computations falling into the second operational classification are found.

This combination of numbers according to a definite mathematical function uses the machines to a fuller extent and is of somewhat greater interest in that it utilizes the equipment in its entirety. A typical problem encountered in the student registration project is the evaluation of secondary schools. The problem called for finding the average grades of all students selected from a particular preparatory school. Mathematically the problem was the computation of the summation:

$$\frac{\sum_{a}^{b} F(x)\Delta x}{\sum_{a}^{b} \Delta x}$$

where $F(x)\Delta x$ is the grade of each student, and the summation of Δx is the total number of students from the school under consideration. In this case, it was necessary to rearrange the cards according to secondary school, insert trailer cards after each school's set of cards, run the cards through a machine which would add both the grades and the number of cards, compute the quotient, and punch the result on the trailer card. It was then necessary to remove the trailer cards and rearrange the student cards in their original order. The trailer cards were then ready for any subsequent treatment deemed necessary.

Much attention has recently been focused on the analysis of meteorological data with IBM machines. These problems are made extremely complex by the large number of variables introduced — year, latitude, longitude, day, week, etc. are but some of the variables, and these do little more than set the boundary conditions for consideration of wind velocity and direction, temperature, and other controlling factors. If rapid, accurate, long-range weather forecasting is to be feasible it will be necessary to rely constantly on automatic computing machines of the type under consideration.

All mathematical problems inserted into these machines are reduced to the basic operations of addition and subtraction. Two machines use two different variations of these procedures in the reduction to fundamental processes. By straight successive addition a product may be computed thus:

$$227 \times 36 = 8172$$

		2	2	7		2	2	7
	2	2	7			2	2	7
3	2	2	7			2	2	7
	2	2	7			2	2	7
					6	2	2	7
						2	2	7
						2	2	7
					8	1	7	2

To perform the operation, the machine starts in a row whose position to the left of the decimal point is numerically equal to the sum of the numbers left of the decimal point of the two numbers to be multiplied. Then one of the numbers is added to itself the number of times indicated by the first digit in the other number. When this process is completed, the machine shifts over another row and repeats the process using the second digit of the second number. This continues until the product is determined.

By breaking up the multiplications into left- and right-hand components a much greater speed is obtained:

$$227 \times 36 = 8172$$

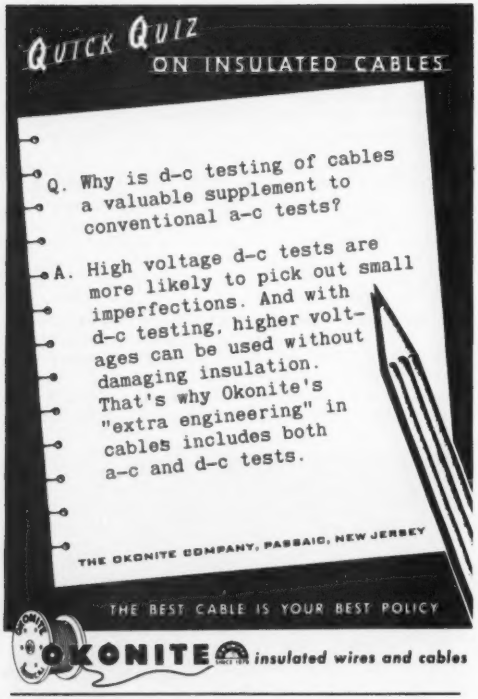
	Left-Hand Components	*Right-Hand Components*
	114	222
	002	661
	0134	6832
	6832	
Answer	8172	

To more fully understand this process, consider the first set of successive additions. Six taken seven times is forty-two. The right-hand component of forty-two is two while the left-hand component is four. Two is placed in the first column under "Right-Hand Components," while four is placed in the first column under "Left-Hand Components." In like manner the second set of successive additions causes two to be placed in the second column under RHC's, and one to be placed in the second column under LHC's. The sum of the two components is found and the RHC is displaced one column to the right and added to the LHC to give the final product.

This listing tabulator takes information punched on cards and transcribes it onto a printed page. It can add information stored or calculated by the machine itself.

Division is accomplished by an analogous method, and other mathematical processes are performed through repeated application of these procedures. It can readily be seen that any number expressible in the form of a mathematical function can be obtained to any desired accuracy by continuous repetition of these fundamental

(*Continued on page 46*)


QUICK QUIZ
ON INSULATED CABLES
Q. Why is d-c testing of cables a valuable supplement to conventional a-c tests?
A. High voltage d-c tests are more likely to pick out small imperfections. And with d-c testing, higher voltages can be used without damaging insulation. That's why Okonite's "extra engineering" in cables includes both a-c and d-c tests.
THE OKONITE COMPANY, PASSAIC, NEW JERSEY
THE BEST CABLE IS YOUR BEST POLICY
OKONITE
insulated wires and cables

the planner and society

(*Continued from page 13*)

create homes. He cannot build a city; he must renovate the physical structure of what he has been given to work with.

In recent years decentralization has been the theme. In many instances the ring of satellite cities surrounding a metropolitan center has grown larger than the central city itself. The suburb is largely a result of modern technology; without rapid transportation it would be impractical.

Middle class Americans have flocked to the suburbs in hoards. But decentralization is beyond the means of those who need it most; the lower classes remain packed together near the city's core.

The importance of the suburb is easily overestimated. It is a specialized unit; generally it is a segregated unit. While it is physically attractive, it is socially incomplete. The group living there has much of its activity centered in the nearby city.

What does the city planner propose to do?

* * *

Sociologists believe that the social atmosphere of a small town is the most healthy. Where everybody has a place in the community, there is a sense of belonging to something, and of being more than a functioning part of a vast economic machine. The individual counts. In most small towns people from all walks of life work together; class boundaries are broken. The individual has a better rounded knowledge of the workings of his community in industry, business, and government, as well as society.

The city, too, has certain advantages besides those of an economic center. It is a cultural center. For a long time the city dweller was always portrayed as more polished than his country cousin. Even today, when smaller communities are usurping much of the polish and sophistication once associated exclusively with the city, the centers of culture, economics, and politics remain in the big cities.

If there were only some way to combine the advantages of both! Why not?

Perhaps the most important idea in city planning today is the neighborhood concept, which would bring small town atmosphere under the shadows of the skyscrapers. Unfortunately such plans are still on the drawing boards.

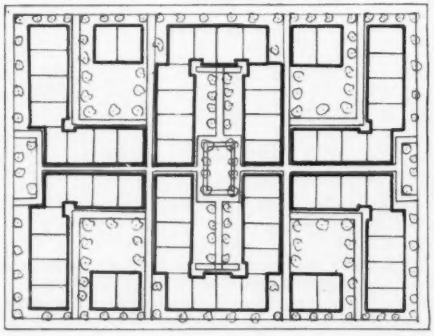
The neighborhood concept would require social decentralization, with a de-emphasis on physical decentralization. Physical rearrangement would be important. Replacement of existing structures would be a long-range objective. Social decentralization consists largely of social regrouping, a redefinition from vague social

Every city block must be integrated into the community. The usual way to build a city block is to place rows of houses along the streets. Such rows of houses are built with no thought of social function. Land which might otherwise serve a useful purpose is divided into parts so small that they are useless.

On the other hand an integrated block utilizes all of the given space in such a way that everybody in the block can benefit by it. Often it is advisable to make the area enclosed within the block larger, but the same density can be maintained, as shown here.

Here again planning is necessary. But the social atmosphere is improved. Children have space in which to play. Physical barriers to sociability such as foreboding back fences and alleys are eliminated. Instead an open block fosters intimacy.

A city can be integrated and functionalized in every detail, only by careful planning. Even the most minute parts of the city can be made more useful, and better suited for people to live in, through careful planning.



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ties which have little effect on most of the population, to a number of concrete neighborhood ties in which the individual is vitally important.

The size of the neighborhoods would vary, but they would be centered around common facilities, and bound by these facilities rather than dispersed by a lack of them. Roadways leading into the community would be planned to serve the immediate neighborhood. Arterial highways might well be used to suggest boundaries between neighborhoods. The physical outline of new roadways could be used to good advantage as a socially unifying factor as well as to speed up transportation.

Of necessity compactness would be a theme of the city-neighborhood. Built in an area of high density, it could not spread like the ordinary small town. The city-neighborhood does not require that a new city be built, but that the existing one be reorganized into socially and physically practical, workable units. Through sensible long-range planning this can be carried out over a period of years. Complete demolition and rebuilding of an area in a short space of time is not necessary.

A city's social structure cannot be directly manipulated. Although society cannot be put on the drawing board, and made to order, physical elements can be planned to affect the social organization. The city-neighborhood serves to improve the social structure indirectly through its physical properties.

A city of neighborhoods would be the most difficult to plan. Mass housing projects would not meet the social requirements. There are no model cities built on such a principle. Every intricate detail would have to be worked out carefully, perhaps tried out and readjusted many times.

Is it not worth the price?

the graduate engineer in industry

(*Continued from page 21*)

they work and how they serve the company and you may decide to enter this very interesting field.

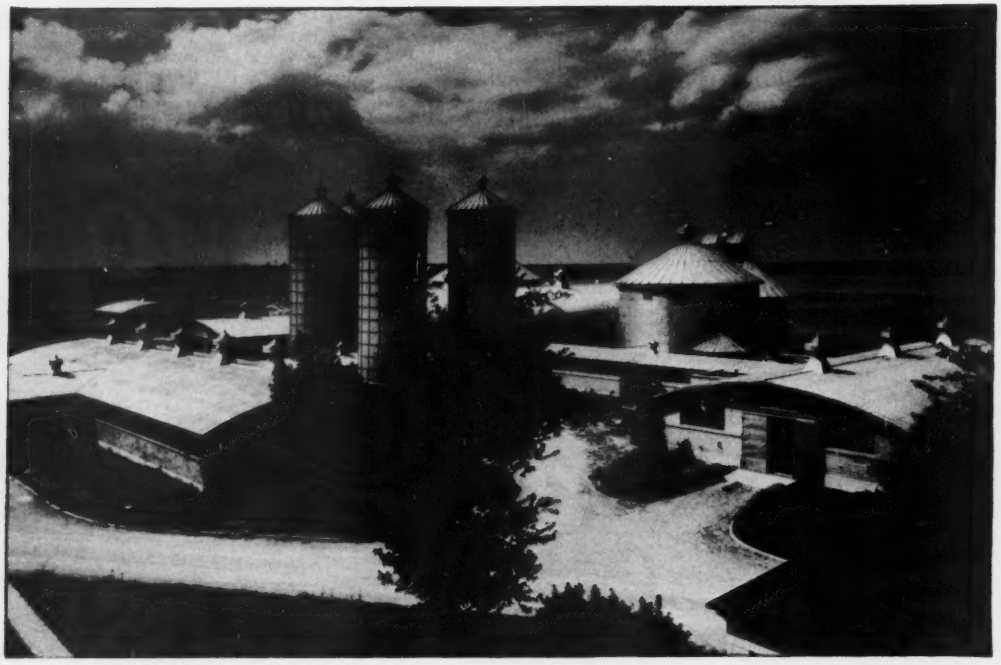
If you prefer to make your career in the development phase of engineering, testing and improving a product, you will find that the Test Engineering Department is the place to start. The work becomes more and more demanding and the responsibilities larger as you advance from the position of mechanic or tester through the grades of Test Engineering and Project Engineering. From here you can branch out into staff functions, sales, field engineering, or management. Perhaps this reveals the opportunities open to the ambitious and intelligent engineer.

Starting out in development, the engineer should know something about the job of mechanics who will prepare and run his tests. A half-year's work as a tester, working on engines, at the instrument panel and on the test equipment will teach you the practical difficulties connected with running a test and give you an understanding of the men and their responsibilities.

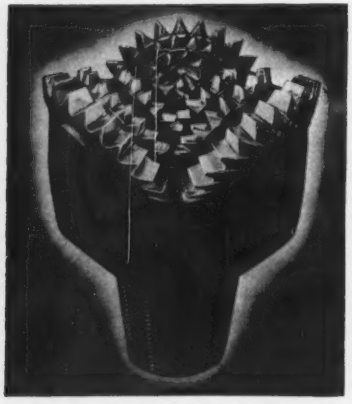
As a junior test engineer you will be given small testing assignments on components and accessories. As you begin to understand more about your work and how the tests are evaluated, larger assignments are entrusted to you. The senior test engineer in charge of the test program on a given engine will direct the other engineers who are investigating particular problems connected with the engine. Together they will attempt to discover the weaknesses and limitations of the parts they are testing, analyze them for improve-

(*Continued on page 40*)

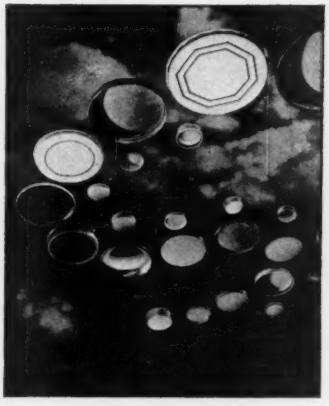
Only STEEL can do so many jobs



PRELUDE TO A SQUARE MEAL. Today, about 12½% of our population works on farms and ranches, supplying food for America and the world. And steel, more than any other material, has helped to make their work easier, their production greater, their lives pleasanter. For steel not only gives them strong, weather-proof roofing and siding for farm buildings like these, (U·S·S Stormseal and U·S·S Tenneseal are famous names in rural areas) but helps to bring them modern farm machinery and equipment, the blessings of electricity, fast transportation and scores of other benefits.



THE CAP IS THE CLIMAX. Many of the things we need to keep us healthy and happy these days come to us in handy, closed containers. And the caps, or closures, of these containers are actually the climax to a painstaking effort on the manufacturer's part to keep the container's contents pure and safe. Last year, 53,592,563,699 of these closures were used in America—many of them made from U·S·S Tin Plate... steel with a very thin coating of tin.



KEY TO BURIED TREASURE. This is a rock bit, the steel drilling tool that chews its way down through the earth to tap our deeply-buried treasures of oil and gas. For such bits, U·S·S Alloy Steels supply the super-strength, the extra toughness, the high resistance to impact, shock and abrasion needed for drilling to great depths.

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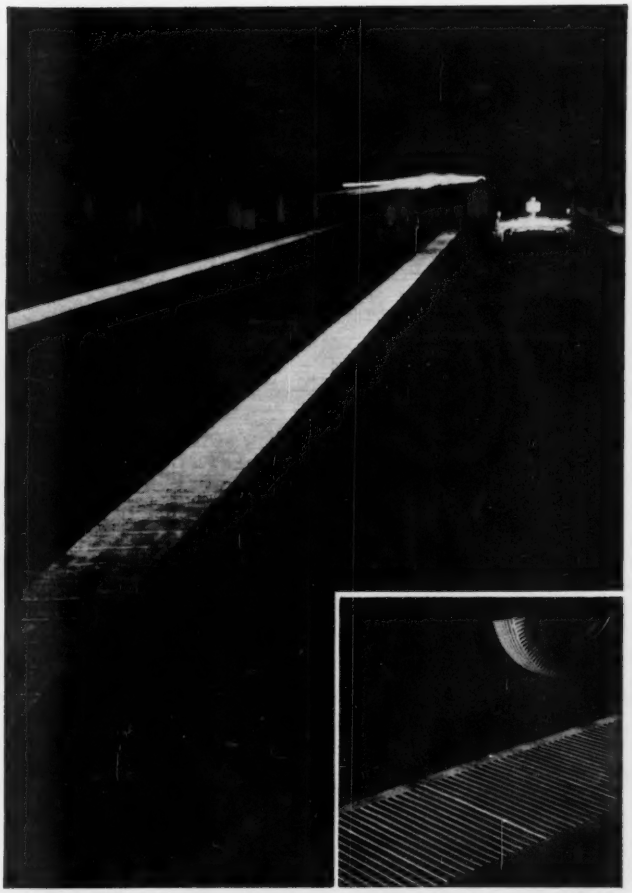

ROAD SEPARATOR THAT TALKS. Supplying reinforcing steel and cement for modern highways is one of the important jobs of United States Steel. Making highways safer is another one. This traffic lane marker, developed by Universal Atlas Cement, does double safety duty. Made of Atlas white cement, it is clearly visible at night. And its corrugated design (inset) actually causes it to sound a plainly-audible warning should you veer out of lane and your car tires ride on the corrugations.

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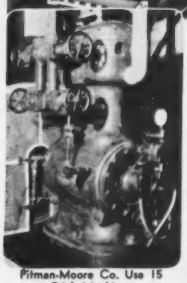
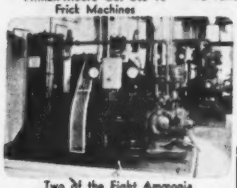


Pitman-Moore Co. Use 15 Frick Machines

FRICK Refrigeration Serves Famous Biological Lab.

Pitman-Moore Company, Division of Allied Laboratories, Inc., recently celebrated its 50th anniversary as a producer of biologicals and pharmaceuticals for human and veterinary use. ● Its plants at Zionsville, Ind., (shown above) and Indianapolis are equipped with 15 Frick machines totaling 92 tons of refrigeration. These are used for air conditioning, processing and storage work. Installation by Hayes Brothers, Inc., Frick Distributors at Indianapolis.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.



Two of the Eight Ammonia Refrigerating Units

FRICK CO. WAYNESBORO, PENNA.

Also Builders of Power Farming and Sawmill Machinery

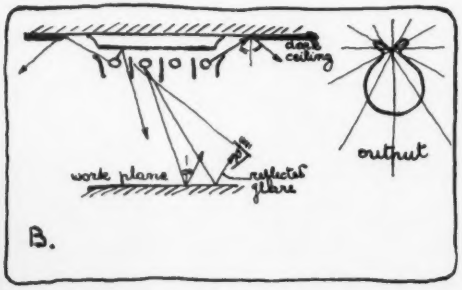
from point source to luminous ceiling

(*Continued from page 17*)

Translucent plastic has been found most successful, however. Perfectly even brightness and pleasant low surface glow result from plastic-covered luminous ceilings. This lighting system is now commercially available.

II. The Reflecting Surfaces

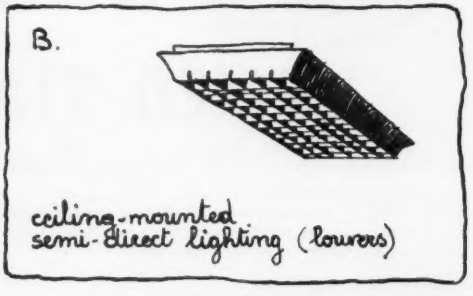
Dark or shiny surfaces in a room used for intense visual work can be just as harmful to the eyes as the crudest of luminaires. Elimination of glare from the light source itself is only half the job in the design of a modern lighting system. Low brightness ratios cannot be obtained in a room which has large expanses of dark paint or woodwork as these are always in sharp contrast to even the most evenly spread low-brightness source. Blackboards in classrooms are the worst offenders in this respect, and it is hoped that light-colored chalkboard using dark chalks will some day supplant the old-fashioned blackboard.

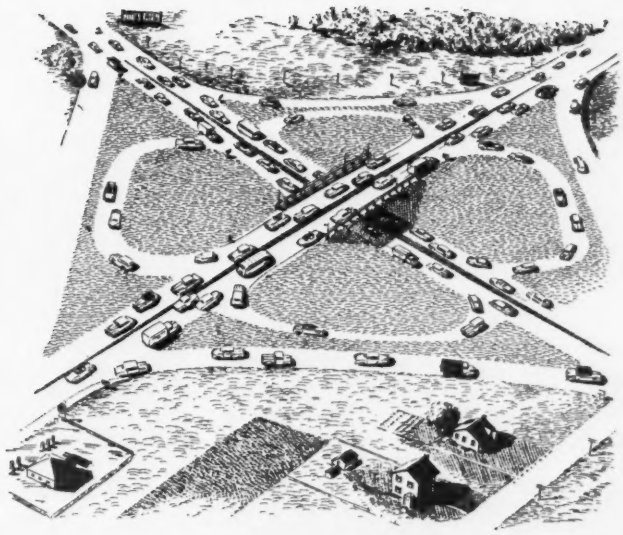


Similarly, any surface on the working plane which is shiny enough to reflect an image of the lighting source will create a patch of glare. Ideally good luminaire design should be accompanied by walls, ceilings, floors and furniture made light in color and with a dull matte finish.

In order to experiment with these modern trends in lighting, particularly as related to school lighting, the administration at M. I. T. appointed a Lighting Committee. Since its appointment in 1946 the Committee, consisting of Professors Herbert L. Beckwith, Parry Moon, and Mr. Carl F. Peterson, has brought about the installation at Tech of several systems based on the criteria discussed above. In all cases the basic desire was to expand the source of light into an apparent source of the largest possible area, in most cases the

(*Continued on page 36*)





The forgotten half billion

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A CENTURY OF CONFIDENCE

prestressed concrete

(*Continued from page 11*)

b. Stressing the steel, before casting the concrete, by reaction against an abutment separate from the element, e. g., on the mould.
c. Special methods, chiefly applicable to cables which are not straight.

As contrasted with ordinary reinforced concrete all forms of prestressed concrete involve the problem of end anchorage of the steel. In systems *a* and *c* above the anchorage becomes a permanent part of the structure while in system *b* the anchorage is only temporary and is released after the concrete has hardened. It is natural that most of the research on this subject has been centered on the problem of simplifying the anchorage detail.

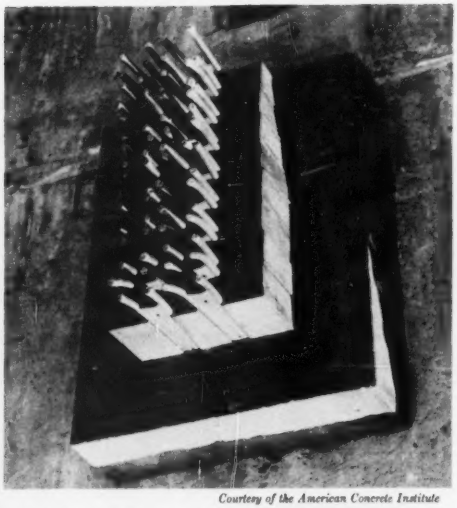
Courtesy of the American Concrete Institute

Prestressing cables in the Bourg d'Oissans Bridge in France.

The tensile strength of the steel employed in prestressed concrete is always the result of special treatment, and because of the essential need to avoid any cause of weakness, all operations altering the properties or section of the metal must be avoided.

The simplest anchorage of the prestressed wires is that by bond which consists of embedding the wires in the concrete. It is obtained automatically by casting the concrete around the wires. When the concrete has hardened sufficiently, the release of the temporary anchorage stresses the concrete. The anchorage by bond can give good results provided that sufficient tensile strength of the concrete is assured, and that there is sufficient length between the end of the wires and the section in which full prestress is required. The systems of Freyssinet and Magnel, however, do not depend on the bond between steel and concrete. In both cases the wires are kept in stress by conical and flat wedges respectively, and these anchorage units are embedded in concrete and left on the structure permanently.

Applications of prestressed concrete so far concern mainly elements of small dimensions precast in the factory, and, at the other end of the scale, very large structures cast in the field. To overcome the customary resistance to revolutionary types of construction, much effort has been devoted to simplification of the present methods of prestressing. In all spheres where practical results have been achieved, they are still far from perfect



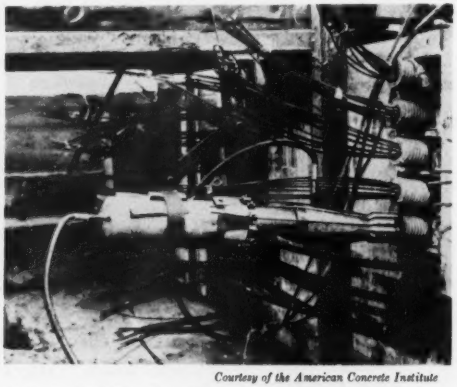
Courtesy of the American Concrete Institute

Arrangement of Magnel sandwich plates for anchoring prestressed wires.

owing to the fact that insufficient time has yet been devoted to their development.

In general it may be said that the cost of prestressing diminishes as the value of the works increases; on the one hand, in proportion to the size of the units, and on the other hand, in proportion to the amount of repetitive work where there are many identical members.

Prestressed elements are today prefabricated in factories in most European countries and also in Algeria, Australia, French Colonial Africa and in the South



Courtesy of the American Concrete Institute

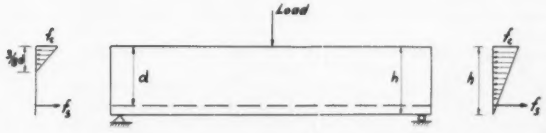
Freyssinet jack and prestressing cables.

American countries, and to a very limited extent in the United States. These precast elements have been made for many usages, such as: railway ties, pipes (cast and prestressed in one operation), reservoirs (precast sections assembled by prestressing in two directions), bridge decks (the area of prestressed concrete deck

construction is now growing at a remarkable rate) foundation piles, harbor works, dams, buildings, and airport runways and roads.

The construction of the Walnut Lane Bridge in Philadelphia, which is now nearly completed, is hoped to be a forerunner of what will be common practice in the future in this country.

The success of any method of construction depends largely on its cost compared with that of other methods that solve a structural problem equally well. The costs of ordinary reinforced concrete are not strictly comparable in the case of a structure that must be free from cracks, or of restricted dimensions, or quite impermeable. For example, a reinforced concrete tank to contain gasoline must be treated to ensure tightness, but large prestressed concrete gasoline tanks are reported to be successful without treatment. There is yet insufficient data available to compare the cost of prestressed concrete and ordinary reinforced concrete in cases where either material is suitable. Most new methods of construction are, in their early stages, more costly than after they have been practiced for several years and on various types of structures. It may be that, due to the need to save steel and timber, prestressed concrete may see sufficient use to enable the heavy initial costs to be spread over such a large volume of work that this type of concrete will in some directions be able to compete in cost with reinforced concrete and other materials. Abroad, where materials are relatively scarce and expensive, and labor is less costly, prestressed concrete has developed particularly rapidly. The lessons learned from prestressed concrete (in particular the usage of very high quality steel and concrete) may also permit a reduction in the relative cost of ordinary reinforced concrete.



This figure illustrates the differences in the design stresses at midpoint of the beam by the conventional method (left) and the prestressed (right). f_c is the maximum compressive stress in the concrete; f_s is the tensile stress in the reinforcing steel.

Prestressed concrete can in some cases today compete economically with other types of construction. While it is natural to assume that present-day relative cost of prestressed concrete may, with gain in experience, be lowered, it is unlikely that in the future the relative cost of ordinary reinforced concrete will be lowered. The combined effect of stronger concrete and steel and improvements in design and construction may not only lead to reduction in the cost of reinforced concrete but may impart to reinforced concrete some of the principal properties of prestressed concrete, such as less risk of cracking because of less shrinkage and higher tensile strength of the concrete.

The activity and interest in the field of prestressed concrete is now rapidly increasing in this country. It is very likely that American engineers will contribute in this field by developing new methods of prestressing as well as finding new fields for application of the system.

the brain

(*Continued from page 15*)

shame of witnessing another man's naked suffering. Gradually the sobs subsided. Again Waterman took up the inquisition.

"Now, don't bother yourself to put it all together," he said. "Just let me ask you questions. It will all come out easier that way. Let's see. What sort of a place was this Goodair?"

A. "Oh, just one of those farming towns, set down on the prairie by pure chance. It was a farming town; that is, except for the factory."

Q. "The factory — what was that? What did it make?"

A. "I never could tell. The people in the town — well, you couldn't believe a word they said. You know the gossip in a small place like that."

Q. "What sort of gossip?"

A. "Some people said it was a bootleg headquarters, and others that it was a headquarters for making drugs. Anyhow, I never liked the place."

Q. "Why not?"

A. "It was a low building of crumbling concrete left over from World War I. I took a walk over there one day. I always felt that somebody was watching me, and I didn't dare to go very near. It was surrounded by a tangle of giant pigweed, and ditches half-filled with a scummy green water. There were a lot of dismantled wrecks of old cars there, and some neglected farm machinery. Nobody ever seemed to go there for weeks at a time, but every now and then we saw a big car drive up just about dusk."

Q. "What sort of a car?"

A. "It looked like a fancy limousine, but it drove like a truck — and the man in it — ."

Q. "When did you see the man?"

A. "That was when the car was coming down our road at about eighty miles just before — Oh God! I saw my car open up like a wet paper boat and spring across the road. They were in it. My Paul — my Martha — my poor little Paul."

Cole became inarticulate again; he twitched all over. I have only seen the like in an experimental animal on the operating table. Waterman gave him another dose. I don't know whether of sedative or stimulant, and Cole gradually quieted down.

Q. "Tell me about the man in the car."

A. "Tall and fat and well-dressed. A red scar went from the corner of his eye to his mouth."

Q. "Do you remember what they called him?"

A. "Macaluso, I think. But they never spoke of him by his name. The country people didn't talk of him much, but when they did they called him *The Brain*."

Q. "Was he the man who made the drugs?"

A. "I think so, but a friend of mine told me that he was a big-shot bank robber, too. A slick article, they said. The police had been looking for him a long time, but they hadn't been able to get anything on him which would stick."

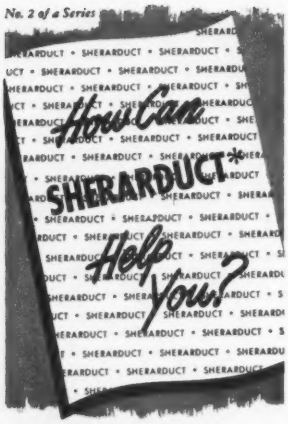
Q. "What happened after the accident?"

The patient made as if to answer, but the words would not come through his mouth. The doctor waited silently until Cole seemed to take hold of himself. He spoke bitterly, forcing his words between his teeth.

A. "It broke my wife's back," he said. "From then to the day she died, she never walked one step.

(*Continued on page 34*)

No. 2 of a Series



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Sherarduct is but one of many outstanding products made by National Electric—a reliable source of supply for any electrical roughing-in materials that you might need.

the brain

(*Continued from page 33*)

My boy had the left side of his skull crushed in against the seat in front. When I saw it, it was flat and utterly without shape. My partner at the hospital was a good man and saved his life. That is, saved him as a blind, deaf, paralyzed, healthy lump of flesh. With the care that he will get in an institution he will probably outlive most well children. You know what that means. Care that you can't get at a state institution and money — money — money. Or else that I would have to live all my life with this horror right in front of me. My God! It can't be real. It isn't real."

Q. "Didn't they ever try to compensate you for the damage? Of course, I don't mean that they could really compensate you, but you must have needed a lot of money to take care of your wife and child."

A. "They tried to compensate me, all right. A few days after the accident, I was approached over the phone by a local lawyer named Peterson. Peterson was regarded as a pretty slick article in the village. He wanted to know some lawyer representing me whom he could get in touch with. I had a friend named Epstein who did some of the hospital's legal business, so I gave Peterson his name. Epstein told me to keep off the telephone, and to stall Peterson until after he had a chance to talk with me."

Q. "What happened then?"

A. "Epstein came over, and I asked him why he was so cagey. He told me that Peterson was hand in glove with Macaluso and did his legal business for him. He also told me something about the Brain's connections and his tie-up with the county authorities. It did not seem possible to do anything against him. While Epstein was talking Peterson came in. He had a dapperly-waxed little moustache, a frock coat, and an eyeglass hung on a black ribbon. I didn't like the sight of him, but I must say that he was polite."

Q. "He made you an offer though, didn't he?"

A. "He didn't let us know who his principal was, and he disclaimed all responsibility. He tendered me a check for $30,000 for full release. His patter was pretty glib, but I couldn't turn down his money. I would have taken it, if Epstein hadn't told him that we couldn't sign the paper for less than $50,000, as the hospital expenses were going to be so severe and long-lasting. Peterson made a show of protest and I had the good sense to keep quiet. Finally Peterson came across with an offer of $50,000, and Epstein advised me to accept it."

Q. "Well, that compensation must have left you in a financially possible position. What happened then?"

A. "There wasn't anything we could do about Paul. He could eat and he was healthy enough in a vegetative way, but he wasn't my child any more. He had to stay in bed, and he was blind, deaf, and paralyzed. There wasn't a trace of intelligence to be seen. We managed to get him taken at one of the few institutions for cases of that sort, but he was scarcely enough of a human being for us to see him except at long intervals."

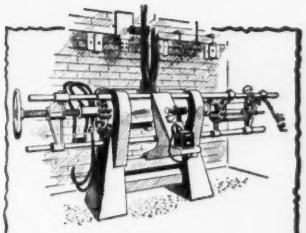
Q. "What happened to your wife?"

A. "They took care of her at the State General Hospital about twenty miles away. At first she did pretty well, and then I even thought of building a special house for her with ramps and special kitchen equipment. However her kidneys had not been too good for years and that is always the weak point for paraplegics. She went downhill rapidly. In about three months she sank into a euremic coma, and never opened her eyes again. She died in the late fall, but mercifully my colleagues in the hospital were good to me, so we could be together as much as possible in the last days. The funeral was at her home in Minnesota. Her father was a grim old Swedish farmer and did not say much, but I could see he was a broken man."

Q. "I don't see that there was anything left to keep you at Leominster. Did you go back?"

A. "Yes, I did. The train from the West came into the station at about ten in the evening. I noticed two rather strange-looking fellows loitering about and they seemed to be waiting for me. One was a big six-foot bruiser with a broken nose. The other was a lean, wizened, sallow man of ordinary height. He wore a tight overcoat, kept his hat well over his eyes and his hands in his pockets. The prize fighter sidled over to me and said in a hoarse, wheezy voice, 'We've got a job for you. The Boss is hurt.' 'The Boss,' said I, 'do I know him?' 'Sure you do,' wheezed the prize fighter. 'Everybody knows him. You know him. They call him the Brain. We was driving down the turnpike at a pretty fair clip (it wasn't

(*Continued on page 44*)



The hardest material made by man is which of these?

- ☐ *Silicon Carbide*
- ☐ *Tungsten Carbide*
- ☐ *Boron Carbide*
- ☐ *Carbon Tool Steel*

The answer is Boron Carbide (B_4C), produced by Norton under the trade-mark NORBIDE*. To make NORBIDE Boron Carbide, two of the most commonplace substances — carbon, in the form of coke, and the familiar household boric acid — are fused in electric furnaces at approximately 5000°F, almost twice the melting point of steel. The result is the hardest material ever manufactured commercially — harder, even, than any natural precious stone except the diamond!

In the Norton Research Laboratory, William C. Arthur, B. S. in A. E., Cornell '48, studies a problem in abrasive development.

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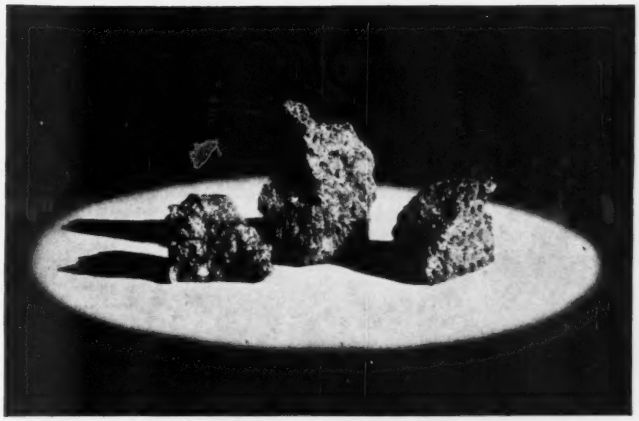

Crude NORBIDE pieces as they come from the electric furnace.

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The valuable characteristics of NORBIDE Boron Carbide have provided engineering departments with solutions to some of industry's trickiest problems. In powdered form it is used for many abrasive jobs hitherto possible only with diamond dust. In molded form it is unrivalled for resistance to abrasion. NORBIDE gages and sand-blasting nozzles, for example, outlast their metal equivalents many hundreds of times.

In his work on the development of silicon carbide refractories, Herbert Ueltz, Ph. D., Rutgers '49, removes refractory samples from a high temperature laboratory furnace.

Norton . . . and You

NORBIDE Boron Carbide is but one of many similar Norton achievements, developed throughout a long history of "making better products to make other products better." Young engineers now planning their careers will do well to consider the field of abrasives — and Norton.

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from point source to luminous ceiling

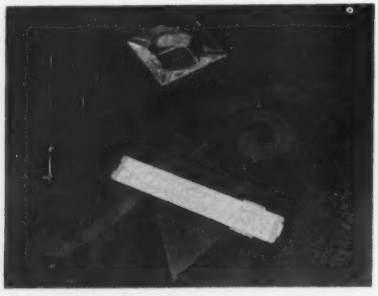
(*Continued from page 30*)

entire ceiling of the room, while eliminating any dark surfaces which would contrast with the source.

The luminous ceiling concept has been tried in Room 2–143 as well as in the Provost's and Mr. Peterson's office. In these rooms, continuous corrugated plastic sheets have been suspended below the actual ceiling of the room. Above these sheets of diffusing plastic are installed continuous rows of fluorescent lamps twenty-four inches apart. Even though this ceiling is

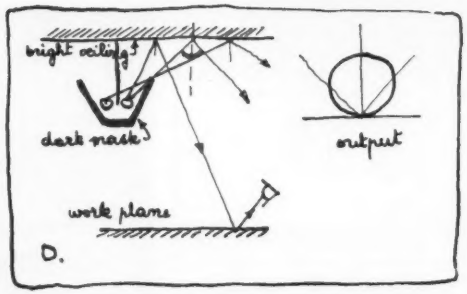
Exposed lamps (in this case in a louvered ceiling) invariably cause glare in any shiny surface.

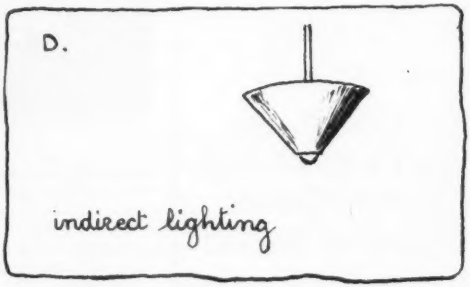
completely without glare (it will not hurt the eyes to look right into it) it provides about sixty lumens per square foot (footcandles) at desk height. This is about fifteen times the light received in the conventional Tech classroom. To make up for the loss of acoustical treatment which is usually placed on classroom ceilings, the M. I. T. Acoustics Laboratory worked with the Lighting Committee to produce a design for a hanging perforated metal fin containing sound absorptive pads which are installed at joints between the plastic sheets. Because the cost of plastic is very high, the sheets were corrugated so that they would have enough stiffness to prevent sagging when one-eighth-inch sheets of the material are used. Maintenance of the ceiling is fairly easy as the sheets of plastic may be slid aside to allow access for cleaning and relamping. To further reduce the cost



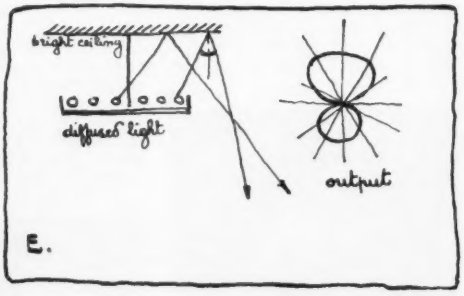
Same instruments photographed under a luminous ceiling are free of glare.

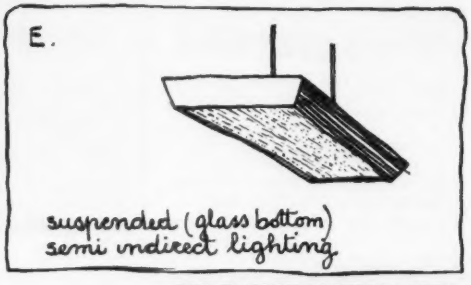
of this kind of installation, work is being done on the development of an inexpensive plastic impregnated paper stretched on metal frames to be used in place of solid plastic sheets.



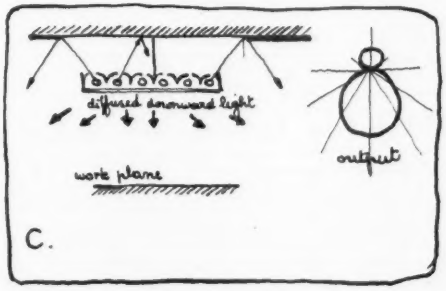


Lower in cost and more practical for present use is the semi-indirect (luminous indirect) lighting system which has been designed by the Committee to replace the inadequate indirect system once used in many drafting rooms. Drafting rooms in Building 1 and Building 7 as well as the President's and the Deans' offices have installations of these new cylindrical semi-indirect luminaires. The upper half of the cylinder is made of clear plastic which allows most of the light to project onto a white ceiling. The lower half of the

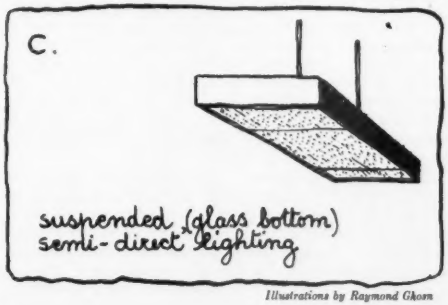




cylinder is made of white diffusing plastic which helps reflect light up onto the ceiling and allows only enough light through so that the visible bottom half of the luminaire is about as bright as the ceiling above. Even though these luminaires hang down into the room, they have been carefully designed to have a minimum of opaque parts and the effect of a room filled with them is that of an even, unbroken glow of light. The two forty-eight-inch fluorescent lamps are protected from the collection of dust by their plastic casing which is in turn coated with anti-static wax to resist the settlement of dust on its outside surface. What dust does collect



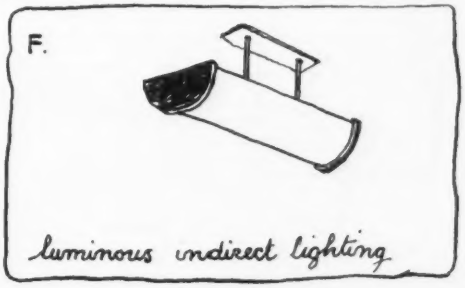
on the top surface of the cylinder may be very easily removed from the ground by means of a simple long-handled mop. The elimination of the dust problem in these fixtures is an important step in the development of an entirely successful design meeting all the criteria for good lighting systems. They are able to provide as much as fifty lumens per square foot (footcandles) at the desk top, thus completely eliminating the need of individual desk lamps which always caused shadows and harmfully sharp contrasts between the working area and the rest of the room. The Lighting Committee is making a series of careful measurements of both illumination level and comparative brightness at regular intervals of time, where these luminaires are installed, to determine the depreciation brought about by dust



Illustrations by Raymond Ghosn

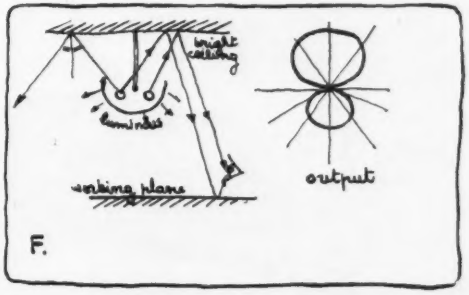
collection and aging of lamps. The recession curve obtained by plotting illumination level against the life in hours of the luminaire shows favorable results as compared with commercially available luminous indirect fixtures. This Lighting Committee luminaire is now being manufactured in quantity and is commercially available.

In Room 2-190 and the Jackson Room a hybrid fixture called the "landing barge" has been installed. Combining the large areas of the plastic transmitting surface used in the luminous ceiling with the use of the



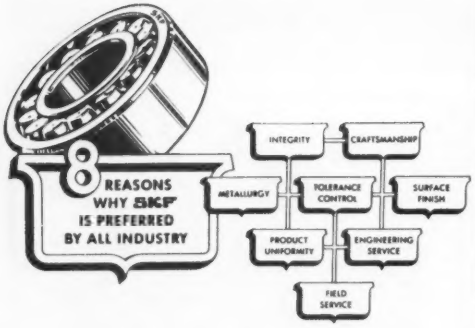
structural ceiling as a reflector, it makes a most attractive luminaire, particularly appropriate in small sectors of large rooms or where structural obstructions make installation of the other types complicated. It has the drawback of open-top luminous indirect fixtures as it easily collects dust on the top of the diffusing plastic.

In all the rooms where the new lighting systems have been installed, great efforts were also made to lighten all the surfaces in the room to bring the brightness ratio as close to the ideal three to one as possible.



In addition to purely physical effect on the seeing mechanism, the introduction of these new lighting systems has a definite psychological impact. The rooms where they are installed have a luminous environment which proves very stimulating and esthetically pleasing. They mark a trend toward more dignified, unornamented lighting fixtures which make artificial light an integral part of the space rather than glaring, self-conscious obstructions.

Work has been made less tiring for the people enjoying the experimental installations of the Lighting Committee in the older Tech buildings. In the new buildings the Committee is following an Institute policy which favors also the installation of luminaires of several commercial lighting companies, at the same time attempting to meet as nearly as possible the criteria for good lighting. Thus the pioneering work of the Lighting Committee continues to make great strides in the provision of pleasant and healthy lighting for the Institute.



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x-ray diffraction

(*Continued from page 19*)

at each end must be exactly in line with the focal spot of the target of the x-ray tube. Other necessary parts of the camera are a lead enclosure for shielding of film, film holder, and an arrangement for the adjustment of the specimen to a proper angle with the primary beam.

The experiment I wished to perform was to photograph the diffraction pattern of a NaCl crystal of simple cubic structure and to mathematically analyze the spots in order to associate them with a particular atomic plane. In order to do this the small pinpoint beam provided by the collimator tube was passed through a very thin section of a NaCl crystal perpendicular to the normal cleavage planes. To obtain a symmetric pattern the crystal must be free from imperfections and must be cut very carefully along these cleavage planes. When a suitable section has been obtained it must be polished in order to assure uniform thickness. After many attempts and failures, I obtained a fairly perfect crystal section and proceeded to photograph its pattern. Figure 2 is the best result obtained after many tries at symmetry and compared to modern standards is very distorted. However, I analyzed one of the spots mathematically and found that the particular spot was reflected from the (113) plane of the crystal. The numbers 1,1,3 are known as the Miller indices of the plane; this is simply a system of three dimensional coordinates used for locating a particular plane in a solid crystal and are represented by the letters (*HKL*). For the reader who is interested in just how the data from the experiment was used in determining the Miller indices the equations are:

$$\tan \phi = \frac{K}{L},$$

$$\tan 2\theta = \frac{r}{R},$$

and

$$\sin \theta = \frac{H}{\sqrt{H^2 + K^2 + L^2}},$$

where ϕ and r are the polar coordinates of the Laué spot measurable from the photograph, R is the distance from crystal to film, 2θ is an angle shown in Figure 1, and H,K,L are the Miller indices. When H,K,L are found, the position of a particular plane of the crystal is known with respect to an origin taken as the corner of the crystal. The above equations are very specialized and apply only to cubic crystals with the x-ray beam perpendicular to a cube face. By treating all of the spots in a similar manner and by using various incident angles a great deal of knowledge can be obtained about the structure of the crystal.

The next experiment I performed was simply a qualitative comparison of the diffraction patterns of $CuSO_4 \cdot 5H_2O$ and $CuSO_4$, the pentahydrous type having triclinic crystalline form and the anhydrous being amorphous. No analysis was tried since the equations applicable to triclinic crystals are very complex. Figures 3 and 4 show the patterns obtained from these specimens which were both in the powdered form. $CuSO_4 \cdot 5H_2O$ exhibits diffraction indicating periodic structure, while the amorphous form gives no pattern and shows the absence of any definite structure. Actually when monochromatic radiation is used an amorphous substance will give a pattern in the form of one broad ring, but very little scattering is evident when continuous radiation is employed.

With experiments such as these as a starting point, early investigators soon expanded their methods to

(*Continued on page 41*)

BELL TELEPHONE SYSTEM

the graduate engineer in industry

(*Continued from page 27*)

ments and then make reports on their findings. These reports give the project engineer in charge of the whole engine an idea of how it is performing and what should be done next. The testing program can then be extended, involving new parts and operating conditions.

Suppose that you are a test engineer and want to put through a change on your engine as a result of a weakness that showed up in the tests you ran. You have pondered the problem and arrived at one or more possible solutions. There remain many questions that have to be answered before you can select the best solution and justify it. In weighing these questions, it is essential that you understand how the other departments operate and what their problems are. The expense of carrying out an experimental change on a single item is different from the expense of a permanent change due to the effect on the amount of paper work, tooling and machining involved. The largest costs arise from the production of parts, and, therefore, you should always attempt to simplify parts when incorporating a change. Thought should also be given to what is already in stock and to available patterns and dies with the intention of making use of these. You should know enough about each department to know where to go to find the answers to those problems you cannot solve. You will not know about all the factors involved unless you discuss the problems with each department, as you will have an opportunity to in your cooperative course.

Left to right: Mr. E. M. Lester, Director of Engineering and Charles Ehlers, '52. A welcome to the Fairchild Engine Division.

The opportunity to work with the mechanics, testers and test engineers in the assembly and testing departments will give you invaluable information on handling personnel and maintaining friendly relations conducive to efficient cooperation. Such knowledge will prove to be a great asset in applying for a job which many other graduates miss. Your work later on will depend on your ability to obtain the cooperation of those around you.

A well-planned cooperative course will allow a detailed study of each department which will give you a real insight into the various jobs that exist, the kind of work that is being performed and the relative merits of each. With such an understanding of the various fields of engineering you are in a much better position to choose your vocation in the final years of your training. You may even turn down your old option in favor of a new one. The work of an estimator, a field engineer, or a tool designer may strike you as interesting enough to become a new goal in your life. Project engineering, sales, design, or production engineering are other fields that may catch your fancy. Any economically minded student should realize that with the large investment he is making in his engineering education it is only fitting that he is fully aware of its potentialities.

So far we have taken a look at industry as it would appear to a graduate engineer starting on his first job and have included some behind-the-scenes pictures of what he would probably not see while he is buried under the details of his own work. Also it was pointed out what a disadvantage it was to the engineer applying for a job if he could not offer any previous experience. The schools and industries in particular have been aware of this discrepancy in a student's training. Their attempts to solve the problem have found a very satisfactory solution in cooperative programs between the colleges and industry. The practical experience offered in this type of program has distinct advantages over most part-time employment that students can get on their own initiative. The fact that both the school and the employer are coordinating their efforts in presenting a student training program and that during the program both are observing the student with an eye to his future prospects and abilities assures the student of a rewarding experience.

There are many types of cooperative programs in existence today and still more are cropping up each year. The mechanical engineers at M. I. T. have been offered their own cooperative program and it is this program that has been discussed here. As you may have learned already, the arrangements made in this program, called II-B, allow the students six months of work in industry during their junior year. No academic credit is given for the work accomplished, nor does the company obligate itself to any commitment for future employment. The school merely offers the student an opportunity to get six continuous months of work and training during the school year with a recognized participating company. The student's courses are rearranged to allow for an absence of half a year. The impressions the student leaves with the participating company will enhance the possibility for future employment with that company; and the experience gained from such industrial work will augment the student's academic record when being considered for future employment by any other company. The opportunity to see how the theoretical knowledge is actually applied will certainly make his senior year at school all the more interesting and fruitful.

This report is largely based on what was learned during a cooperative training period at the Fairchild Engines Division on Long Island, one of the cooperating companies. The program that they have offered the students merits some special attention for the admirable attitude that the company has taken in planning the course and the lessons that all students and companies can learn from their example.

After considering carefully the benefit the company could expect from the students if they were assigned simple work on the drafting board or in the test laboratory and how much the student would learn by doing

(*Continued on page 46*)

x-ray diffraction

(*Continued from page 38*)

include not only single symmetric crystals but also powdered specimens which are really just aggregates of small crystals. Methods were developed to aid in chemical analysis similar to spectroscopy, and eventually the tiny parallel x-ray beam was being turned on many substances such as metals, textiles, and complex organic compounds to learn more about their natures. Better generating apparatus was constructed, and cameras providing for the rotation of the specimen or film were designed.

For an inside look at the present uses of x-ray diffraction in science and engineering there is no better place to go than to the M. I. T. laboratories where all of the modern diffraction methods are employed in research. In the Biology Department Dr. R. S. Bear has been using diffraction in conjunction with electron microscopy in order to determine the structure of various complex protein molecules. Dr. Bear's work centers especially around the protein called collagen. The collagens are contained in the connective tissue and bones of the body and are in some unknown way associated with the degenerative diseases such as arthritis. It has yet to be discovered whether the structure of the collagen is actually changed or if it is involved in some other manner. But before this can be done many experiments must still be performed by means of electron microscopy and x-ray diffraction to determine the structure of a normal collagen. Then the collagens involved in pathological changes can be studied, and it is hoped that knowledge can be gained of just what goes on in the connective tissues of the body when attacked by certain diseases. An important advance in the study of the structure of proteins was made by the discovery of heretofore unnoticed diffraction lines near the center of a diffraction photograph when it was enlarged. These so-called narrow-angle lines were studied and threw much light on the problem of classifying the tissue proteins according to structure. Of course, patterns can be obtained from most all organic compounds, but the job comes in unscrambling this pattern and learning something about the specimen from it. This is sometimes very difficult and often impossible.

Another field in which diffraction can be used very effectively is metallurgy. It is used here in the plotting of the so-called phase curve for alloys, which is a graph of the amount of different types of crystals in an alloy against the temperature. For instance, an alloy of two metals will have different crystal forms at various temperatures. From diffraction data it can be learned what forms are present at certain temperatures and the phase curve can be drawn. Knowledge of this sort is of great importance in the heat-treatment of metals and alloys, including steels. Another important application is the measurement of stress and strain. As it is seen from Bragg's Law the interatomic distance is related to experimental data and can be determined very accurately; it is also known that the interatomic distances increase in the direction of stress. Thus from enough diffraction data the amount of stress can be found. This is very useful in measuring stress and strain in construction that cannot be disassembled such as bridges.

Today, despite forty years of intensive investigation, the field of x-ray diffraction is by no means static. Successful experiments have yet to be carried out on the diffraction of x-rays by a beam of matter waves

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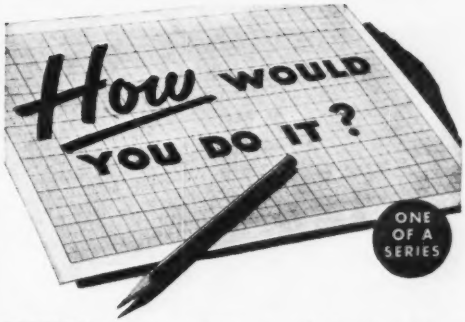

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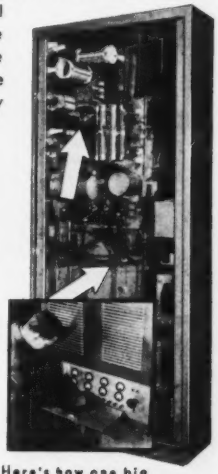

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Graduate Electrical Engineers: RCA Victor—one of the world's foremost manufacturers of radio and electronic products—offers you opportunity to gain valuable, well-rounded training and experience at a good salary with opportunities for advancement. Here are only five of the many projects which offer unusual promise:

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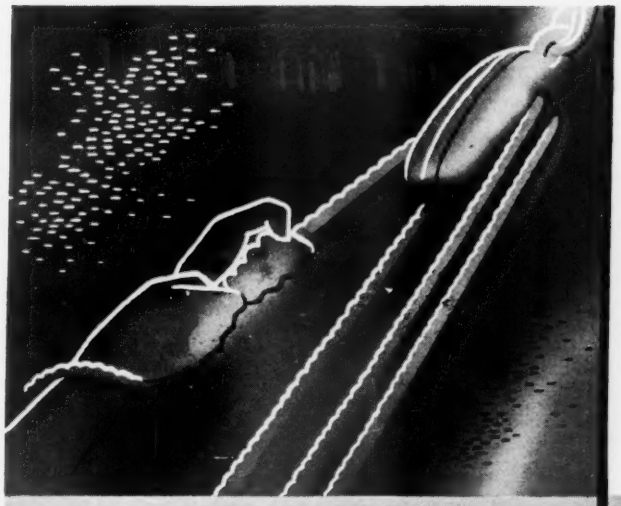

When sail trimming is required

No business can stay healthy without an occasional overhaul of its production set-up—particularly when a seller's market begins to quiver.

Molybdenum steels may be just what the doctor ordered to reduce production costs, and still maintain the product's reputation for consistent performance.

Send for our comprehensive 400-page book, free; "MOLYBDENUM: STEELS, IRONS, ALLOYS."

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MOLY

C4

the brain

(*Continued from page 34*)

more than eighty), when a cow steps into the road. Well, the cow's beef, and the car's junk. It turned over three times. The Brain was thrown up against the windshield and we don't like his looks. We keeps ourselves to ourselves, and we was on private business so we can't take the Brain to a hospital. It's a job down your line. We know you and they tell us you're a guy who can turn out a classy piece of work. We think you're a right guy. If you aren't, it don't matter anyhow. Come along.'

"I said I would have to go back to the hospital to collect my bag. 'Big boy,' said Tight Overcoat, 'be good and do what you're told. Come along.' Then he said to the other fellow, 'Beefy, you talk too much.'

"There wasn't anybody around that I could call and the shops were closed up. I didn't like the looks of the situation, but there was nothing to do but come along. They drove out about a mile and a half to the concrete factory surrounded by lank growths of pigweed and beggar's lice. Somebody yelled out, 'Hey, give us the high sign.'

"Beefy muttered something which seemed to be satisfactory. Then they took me by both arms and hustled me into an office. It was comfortable and even elegant, quite different from what I had expected from the bare boards and broken windows of the rest of the factory. They pushed me into the room and I tripped over the threshold and fell on my face. I got up again and found there were a couple of other men in the room. One of them was Peterson. He helped me to get up. The other fellow was a brisk business executive type in a brown tweed suit. I never did learn his name, but I think he was the Brain's tie-up with big business. Peterson said to me, 'I am sorry that we have got to be somewhat unceremonious with you, but we are not in a position in which we can choose our methods or our manners. We do not wish you any harm, but you must understand that you have got to be discreet. Mr. Macaluso has just had an accident, and it would not be discreet to take him to a hospital. We are depending on you for help, and I promise you that you will be well paid for it.'

"Supposing I say no?" I looked slowly at their faces and turned cold.

" 'In that case, Doctor Cole, we shall have to take measures to protect ourselves. You are an intelligent man, and I am sure you will appreciate the nature of those measures.'

"I hesitated a moment and then made up my mind. All right, I'll do it. Where is the patient? They opened up the door of an inner office, furnished even more luxuriously than the main one. The Brain was sitting on an overstuffed leather chair with his head lolling back over the cushion. His face was covered with an unhealthy deep flush, and the scar stood out even more clearly than I had remembered. His mouth was open. His breath came out stentoriously, and there was a line of dried blood coming from his left nostril, as if a stream had been stenched not more than a minute or two ago. His head was wrapped in a clean towel. 'Mr. Macaluso was engaged in a business trip of a very private nature,' said Brown-tweed. 'His car hit a cow. He was thrown into the windshield. It would be highly undesirable for us, and I may say for you, if any news of his condition should leak out.'

"I unwrapped the bandage. Macaluso's eyes were staring forward into emptiness. The pupils were unequal. I started to palpate the forehead. It was out-of-shape like a watermelon kicked by a horse. As I touched the skull, Peterson leaned forward; Brown-tweed looked at his fingernails, and stood up suddenly as the bone grated when I pressed on it. It was a clear case of depressed fracture of the left frontal bone. I took my fingers away and told Brown-tweed that I would have to operate at once, and that I would have to send back for my tools.

" 'Don't worry about that,' he said. 'We have already taken steps to secure anything that may be needed.'

"He passed me a doctor's bag with J. McC. in gold letters just under the handle.

"Isn't that Dr. McCall's bag?" I said.

" 'It might be,' said the other fellow, 'but that is no concern of yours. How carelessly they do make these car locks.'

"I felt better when I knew I had McCall's bag to work with. His techniques are somewhat different from mine, but anyway I would have a good kit. They were all there — trephine, elevators, electric saw, sodium amytal, novocaine, and alcohol.

" 'Can you make it?' said my new friend.

"I can, said I, hoping I could. I felt very calm and very powerful.

"I looked around for a pan to boil water in and some towels and a good flat table to work on. The business man followed my eyes.

" 'You can use the desk,' he said. 'The Brain won't worry about a few spots on it. The water is already hot in the lavatory, and we have plenty of towels in the linen room. Cupid there used to work as an attendant in the State Hospital until he cooked a patient. That's all right, Cupid,' he remarked. 'It's quite all right to talk before the Doctor.'

"Evidently somebody had known how to prepare for an operation. There were a couple of pair of clean coveralls to take the place of surgical gowns. I put one on, and Cupid put on the other. We laid him out — comfortably flat on his back.

"I got busy. The atmosphere was easier and I first shaved the whole head and bathed it in alcohol. Then I injected the novocaine. When this had taken hold, I injected a deeper local anaesthetic into the tissues around the crushed frontal sinus. I didn't want to use a general anaesthetic because it was too important to watch the return of the patient to consciousness as the pressure was relieved. Then I cut the flap of scalp and heard the grating of the trephine as it bit itself into the bone.

"I must admit that Cupid was a good surgical nurse. He knew just when to pass me a hemostatic forceps on a gauze pad, and he seemed to appreciate what I was doing. Even under these weird circumstances, I must admit that I felt complimented.

"Perhaps the most unpleasant moment of the operation is when the sawed circle breaks off from the rest of the skull. Then there is the problem of stenching the flow of blood from under the dura, the brain's cellophane wrapping. I could see Macaluso beginning to come to life again and I could hear his softer and more regular breathing. He opened his eyes. They had lost their glassy unequal stare and his lips began to mouth words.

" 'Where am I?' he said. 'What has happened?'

" 'Take it easy, Brain,' said the businesslike man. 'You've had an accident. You are in good hands. Dr. Cole is taking care of you.'

" 'Cole,' he said. 'I had a little business with him a while ago. He's a right guy. Can I speak with him?'

(*Continued on page 50*)

Build Confidence ON BROAD EXPERIENCE

by ARCH COOPER
Manager, Empire Region
ALLIS-CHALMERS MANUFACTURING COMPANY
(*Graduate Training Course—1909*)

YOU NEED the confidence that comes from wide experience, whether you intend to be a salesman, designer, researcher, or production man. Confidence based on knowledge is one of the greatest assets an engineer can have. Here is what I mean.

ARCH COOPER

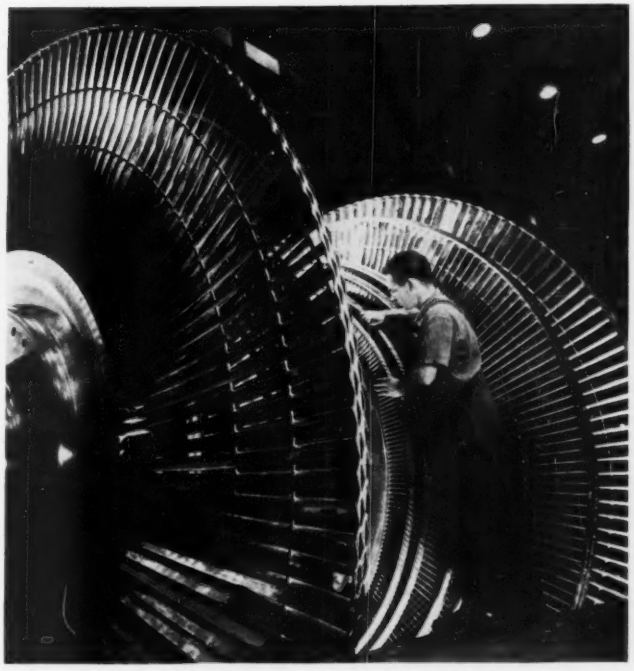
You may visit a mine with the idea of talking about crushing equipment, but find that their engineers have an electrical problem. Or you may visit a utility to talk about electrical equipment and find that they're all excited about a pump break-down.

Offer All-Around Help

Can you help them? Or are you just another peddler who is taking their time when they have problems on their minds. In my work I call on electric utilities, cement plants, machinery builders, textile mills, paper mills, shoe factories and many other types of plants. In each of them, I try to help the engineers and mechanics I call on.

It's a good credo for salesmen, but it takes broad experience to carry it out. It's the kind of experience you must deliberately set about acquiring as early as possible. I had heard of Allis-Chalmers equipment, seen A-C's giant Corliss engines in Australia's biggest power plant and decided to study design at Allis-Chalmers. It looked like the best place in the world to get a broad engineering background.

Textile mills are getting adjustable speed at lower cost by using new automatic Vari-Pitch sheaves on spinning frames as shown.



High temperatures and speeds raise tough design and production problems on giant steam turbine spindles like these.

I joined the Allis-Chalmers Graduate Training Course after graduation from Sydney Technical College in 1908 . . . worked on steam turbines, wound coils of all types, performed tests for the electrical department. After that there were field trips to erect electrical equipment. It was soon apparent that I wasn't a designer at heart, and my sales career started.

Broad Opportunity

Forty-one years later, Allis-Chalmers still offers the same opportunity for broad experience. A-C still builds equipment for electric power, mining and ore reduction, cement making, public works, pulp and wood processing, and flour milling.

And the Allis-Chalmers Graduate Training Course is still flexible. Students help plan their own courses. They can switch to design, manufacturing, research, application, sales, or advertising—divide their time between shops and offices—and can earn advanced degrees in engineering at the same time.

Men at Allis-Chalmers get a close-up of the basic industries. No matter what path they take in the industrial world, experience gained with this broad organization lays a foundation for the confidence that comes with all-around knowledge.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin

partners in creating

For 81 years, leaders of the engineering profession have made K & E products their partners in creating the technical achievements of our age. K & E instruments, drafting equipment and materials—such as the LEROY† Lettering equipment in the picture—have thus played a part in virtually every great engineering project in America.

†Reg. U.S. Pat. Off.

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statistics and machinery

(*Continued from page 25*)

processes. The definite integral can be approximated quite closely by a similar process.

It can be seen from this discussion that there is a definite job performed by punched-card machines. While they are hardly brains, or dangerous creatures for the cyberneticists to attack, they perform an essential job in modern accounting and statistical analysis in a speedy and efficient manner.

At this time, the author wishes to express his appreciation to Mr. Frank M. Verzuh, Director MIT Statistical Services, and Mr. Robert B. Hewes, Assistant Registrar of the Institute, for valuable criticism and numerous suggestions which have contributed immeasurably to the value of this manuscript.

The author would like to suggest, as a collective reference, the many publications of the International Business Machines Corporation, and as general background material about computing machine, also the excellent work of Professor F. B. Murray of Columbia University, *The Theory of Mathematical Machines.*

the graduate engineer in industry

(*Continued from page 40*)

this work and then comparing this with the long range benefit to the company and the educational benefit to the student if the program were to put the accent on acquainting him with the functioning of a whole industrial organization, it was decided that the latter would reap greater rewards. This decision radically changed the whole character of the training program to insure the maximum effectiveness of the instruction. The time is divided among all the departments of the engineering and production divisions according to the relative importance of each to the student. In some departments he will pitch in with the other employees and learn the fundamentals by direct association while in others he will have to observe and question to find out what he needs to know. In contrast to what he was used to in the classroom, he finds that he will become increasingly inquisitive as the complex picture of the organization unfolds itself and he learns the individual characteristics of everyone's job and the way it is performed. This lively interest finds quick response from everybody from the top offices of management to the machinists in the shop to explain and clarify any phase of the company's operation. As a result the student comes away with such a thorough grasp of the factors involved in the organization and functioning of the company that he can intelligently discuss them and, before long, apply them.

x-ray diffraction

(*Continued from page 41*)

such as electrons. Also many complex compounds have yet to be studied by this most powerful tool of research. When enough data has been obtained of complex organic structures it is hoped that the protein molecule — the basic unit of life — can be synthesized. Perhaps some day this method of propagating electromagnetic waves through matter will lead us to an actual understanding of the processes of nature and of life itself.

The author is indebted to Dr. R. S. Bear, Dr. J. T. Norton, and Dr. M. J. Buerger for helpful suggestions and useful information. Also he wishes to thank Dr. B. E. Warren of the Physics Department for reading and checking parts of this paper.

A. FEIGENBAUM

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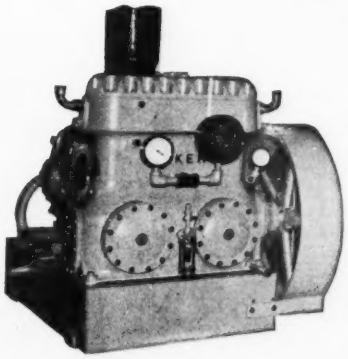
Cameras, Lenses, and Binoculars

EQUIPMENT SOLD, BOUGHT, AND EXCHANGED

Another page for **YOUR BEARING NOTEBOOK**



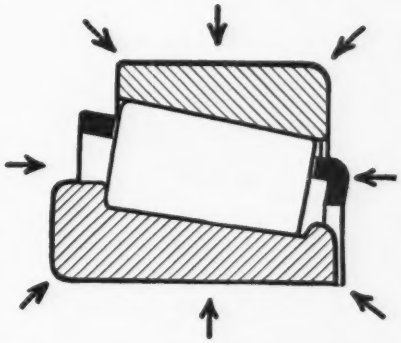
Crankshafts stay rigid ... foods stay frigid

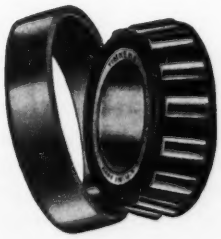
Designers of a compressor for refrigeration plants were looking for a way to insure smooth, dependable crankshaft operation. They couldn't risk the chance of breakdowns—and the food spoilage that might result.

They stopped possible trouble at the design stage—by mounting the crankshafts on Timken® tapered roller bearings. Timken bearings take the heavy radial, thrust and combination loads, prevent shaft wobble, insure trouble-free service with minimum maintenance.

Q: Short on space? A: TIMKEN® bearings!

Because Timken bearings have a *tapered* design, they carry loads from all directions. No separate thrust devices needed. Also, Timken bearings have *line* contact between rolls and races. This gives them greater load capacity, permits use of smaller bearings. The space-saving feature is another reason why 9 out of 10 bearing applications can be handled more efficiently by Timken bearings.





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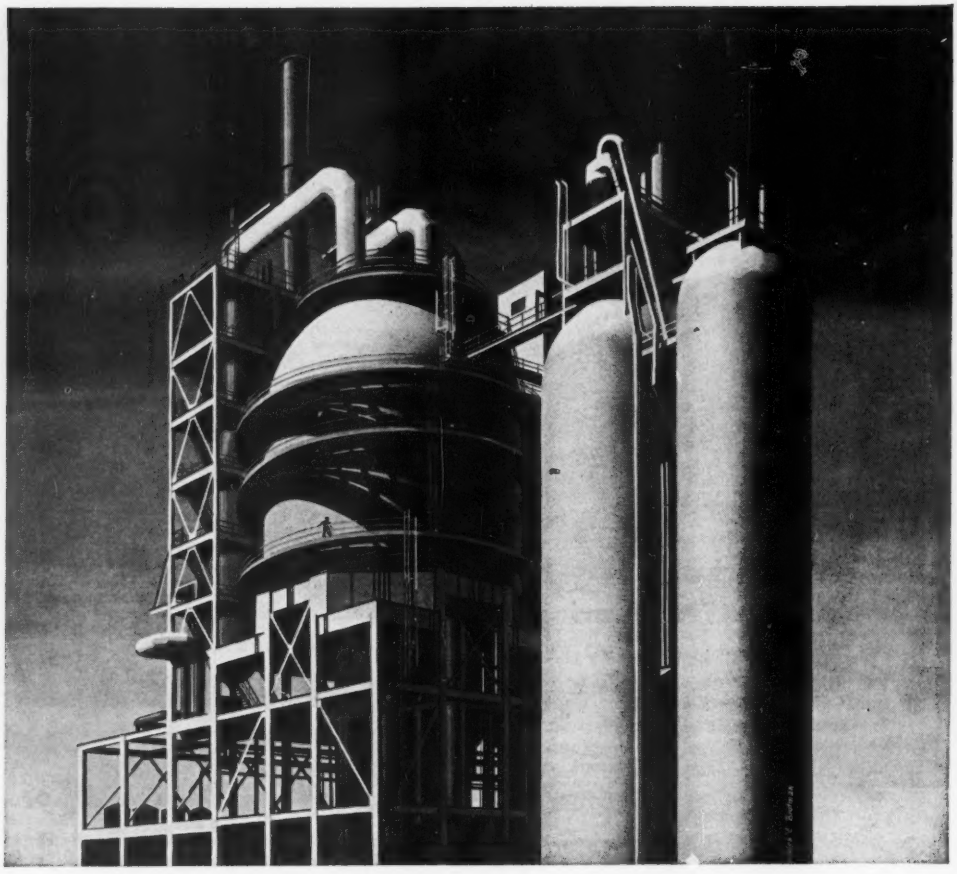
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Want to learn more about bearings?

Some of the important engineering problems you'll face after graduation will involve bearing applications. If you'd like to learn more about this phase of engineering, we'll be glad to help. For additional information about Timken bearings and how engineers use them, write today to The Timken Roller Bearing Company, Canton 6, Ohio. And don't forget to clip this page for future reference.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ◐ AND THRUST ⊣◑⊢ LOADS OR ANY COMBINATION ⊣◑⊢



What's behind the world's champ "Cat Cracker"?

In October, 1949, this world's biggest catalytic cracking plant was put into operation at Linden, N. J., refining oil products for Esso Standard Oil Company.

This behemoth can produce 1,520,000 gallons of liquid power *every day*... that means more heat for homes, more fuel to operate factories and farms, more power to make the nation's wheels go 'round... better living for everybody.

It took a vast amount of scientific skill and achievement, of vision and daring, to build this huge processing plant and put it into operation. Scientific petroleum research and oil engineering progress have always been pioneered and encouraged at Esso.

With the chance to learn and advance on the job, along with fair pay and good working experience... the employees of Esso Standard Oil form a loyal and experienced team, that is constantly striving to improve the high quality and value of products that are sold at the famous Esso Sign from Maine to Louisiana.

Esso

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You're safe until the fire starts

When you go to sleep in a "fireproof" hotel, how safe are you? Consider this: A hotel of "fireproof" construction is very much like a stove. The *walls* won't burn, but the *contents* will. A small flame, kindling at the bottom, can be fanned upward by hot drafts until it mushrooms into a holocaust. In all too many hotel fires, this has been the case.

No . . . "fireproof" construction alone is not enough. Authorities agree that the way to control fire, to hold losses to a minimum, to protect lives, is an automatic sprinkler system. Grinnell Automatic Sprinkler Systems check fire at its source, wherever and whenever it strikes, night or day, with automatic certainty.

LOOK FOR THE GRINNELL SPRINKLER HEADS ON GUARD

Many hotels have provided this complete protection against fire. Look for the famous Grinnell sprinkler heads in the hotel where you stop, in the hospitals and institutions in your locality, the schools your children attend, the plant where you work, in theatres, stores and all public gathering places. They are your assurance of positive, automatic fire protection.

Grinnell Company Inc., Providence, Rhode Island

GRINNELL

FIRE PROTECTION SYSTEMS

ENGINEERING GRADUATES HAVE FOUND ATTRACTIVE OPPORTUNITIES WITH GRINNELL

the brain (*Continued from page 44*)

" 'Here I am,' I said as calmly as I could. 'What have you to tell me?'

" 'I am sorry about that other accident. You took it like a brick. Bygones is bygones. You'll do a good job on me, won't you?'

"I suppose that if he had not flicked me on the raw like this, reminding me of my loss, the whole thing might have come out differently. As it was, I made my mind up. I tried to keep all appearance of emotion suppressed; but I felt white and when I started to reassure the Brain, and tell him that I was giving his case my closest personal consideration and the advantage of my best judgment, Cupid turned around and looked at me in a way that I didn't like.

" 'We are not through yet,' I said. 'Now be very quiet, and I will finish the operation and clean up.'

"I knew what I was going to do, and I don't think I have ever been more deft. At any rate, I was going to settle my relations with Mr. Macaluso once and for all.

"Suddenly Cupid called out, 'Say, Doc, what's you doing? That doesn't look Kosher to me.'

"I said to him quietly, 'This is my judgment and I am taking the responsibility.' I felt I had the upper hand.

"The other fellow from the car, the one who pushed a revolver at me through his pocket, turned to Macaluso and said, 'Brain, Cupid is opening his trap again.' The patient was bandaged except for a small area of operation, but he was perfectly conscious. I like to have them that way in brain operations. It's safer, and besides the brain's surface has no feeling.

" 'That's all right,' he said. 'Cole is a friend of mine. Don't let Cupid hold up the operation. He talks too much.'

"I had completed the debridement, and still had one particular job to do before replacing the bit of skull removed by the trephine.

" 'Look out,' said Cupid. 'He is . . . .'

"The man who had had his hands in his pocket hit Cupid over the head with the butt of his revolver. 'Shut your damn trap,' he said. Cupid lay dead to the world on the floor, and a stream of blood began to creep from one ear. I suppose he had a fracture of the base of the skull, but they wouldn't let me attend to him. I don't even know whether he died or not. I had to walk over Cupid's body to get to the washroom to clean up. When I came back Brown Tweed was waiting. 'Here are $50,000,' he said. 'You understand that you are through at Leominster. If we ever find you in this part of the country again, you know just how long you will last. We will furnish you transportation to the coast, and you can set yourself up in business again under another name. Now remember, or else.'

"I didn't say anything. The money didn't mean a damn thing to me. Nothing did. The Brain started mumbling through his bandages, 'Give him $100,000, boys. I feel fine.'

"I told them what to do for him and took the money offered — ninety-nine shiny new thousand dollar bills and one thousand in fifties and hundreds. They gave me a ticket to San Francisco. Beefy drove me through the night to the Chicago airport. He did not leave me until I was safe aboard the through plane to San Francisco. Once I was on the plane, I took all the money but a few dollars for my immediate needs and folded it up in the big envelope that I found in the pouch behind the seat in front of me. I addressed it to the County Hospital and gave it to the stewardess to mail. Now I had no debts, no money and no friends in this world. It did not seem real. I could go anywhere, and I had nowhere to go. At last I was in a cold sweat, and felt as if the half of me was dead and in the grave. That's about all I remember. I have dim recollections of tramp jungles, freight yards, and riding the rods. How I ever got into Dr. Waterman's care I don't remember. They told me a policeman picked me up for a drunk in a doorway."

Cole had spoken more and more slowly as his drugs took hold, and the rest that he desperately needed began. He closed his eyes and passed into a quiet sleep.

I asked Waterman, "Do you believe this yarn?"

"I hate to say," said Waterman. "The man has certainly been through hell, but there is nothing in what he says that a good imagination couldn't invent. I don't quite get his remarks about what he did to the Brain before closing up the wound. There is nothing particularly impressive about reducing a depressed fracture. Have you any ideas?"

"I don't know," I said. "He could have killed Macaluso on the spot, but he didn't. I don't quite see what he was getting at."

We heard a distant siren growing louder and in a few minutes the ambulance from the State Hospital drove up. Two agile young attendants came in under the direction of a white-clad intern. They picked Cole up, transferred him to a stretcher, and carried him away.

Waterman was tired and sat with us for a few minutes before driving out to the hospital in his own car. We smoked in silence.

"I think he dropped something," said Waterman. "Isn't that a wallet?" It contained a coin or two and a few mementos belonging to his present hospital period.

"Wait a minute," said Waterman. "I think I know something about these wallets. They have a secret compartment inside. Give it to me." He took it and after a little manipulation, he turned it inside out.

"Yes, I think there is a secret compartment. Let's see what's in it."

It contained nothing but a Chicago newspaper clipping two years old. It said:

BRAIN GANG WIPED OUT

PLUTORIA BANK BREAK FLOPS
ONE HUNDRED GRAND LOOT RECOVERED

It went on to tell of a bank robbery attempt made by Macaluso and his henchmen. The attempt had failed grossly. The bank officials were more than ready for the robbers and gave a good account of themselves in the exchange of shots. Those of the robbers who survived to make a getaway were caught between their pursuers and a fast freight where they had to cross the tracks. Not one lived to tell the tale. The paper commented on the incident, remarking that the Brain was known as a careful operator who always planned his jobs well, and that this was the first time he had omitted the most ordinary and elementary precautions.

Waterman took a long puff on his pipe and let the smoke escape upward. I was completely puzzled.

"I don't understand," I said. "It just doesn't make sense. What do you suppose really happened?"

"I don't know," he answered, "but I can guess. In the course of the operation Cole had exposed Macaluso's frontal lobe. It would have been a matter of only a few seconds to undercut it and perform what would be the equivalent of a thoroughgoing frontal lobotomy. It would not have driven Macaluso out of his mind, but would have made him thoroughly unfit to carry out any plans requiring judgment and caution."

I puffed my cigar. "It's not a nice story," I said, "but at any rate, it was a thoroughly successful operation."

Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

BURSTING STRENGTH — In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

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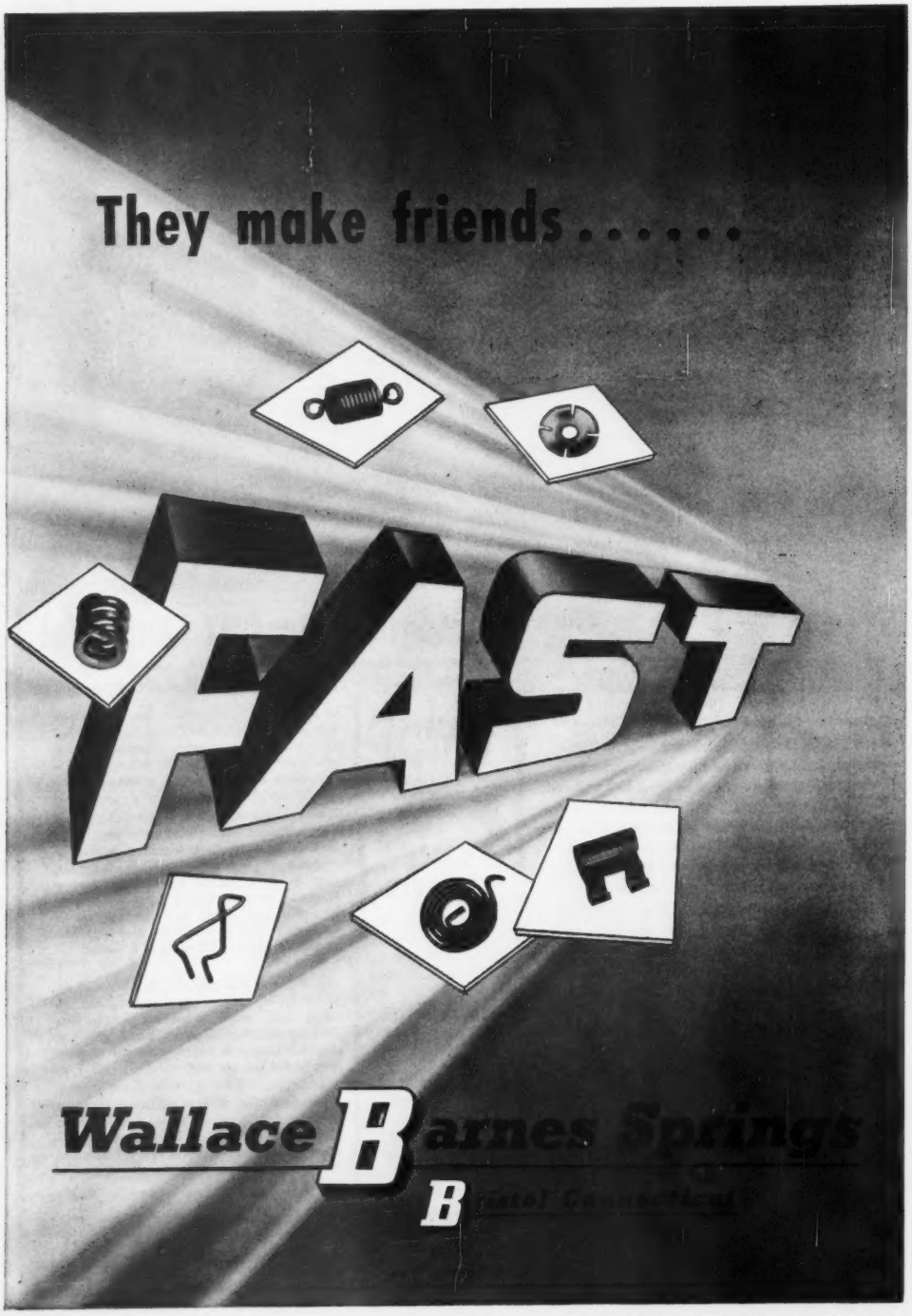
BEAM STRENGTH — When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

Without bursting strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today. But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety. No pipe that is provably deficient in any of these strength factors should ever be laid in city streets. Cast Iron Pipe Research Association, Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON PIPE SERVES FOR CENTURIES


They make friends.....
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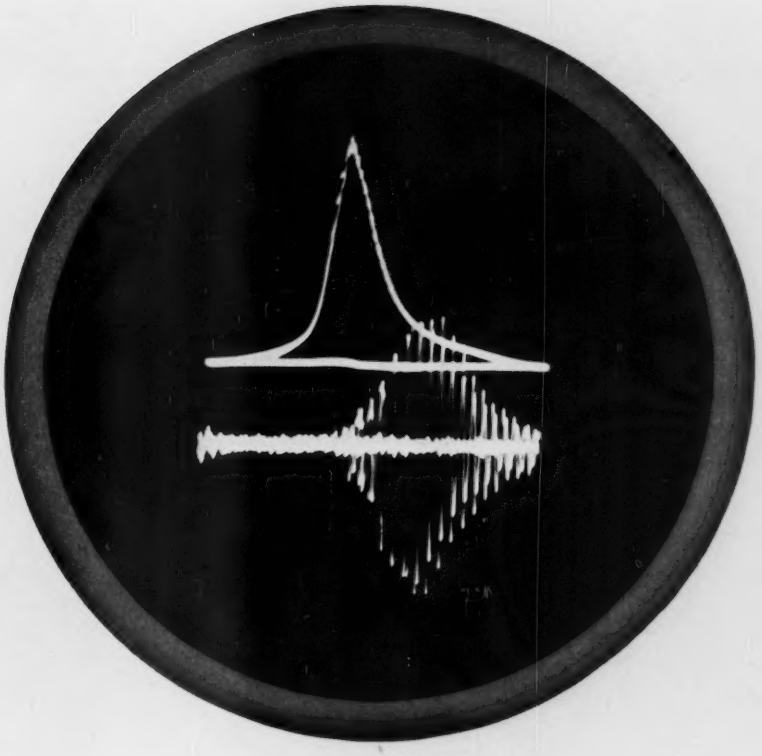

This is a picture of "PING"

It's a picture that gives automotive engineers clear-cut facts on performance—a picture that suggests how photography with its ability to record, its accuracy and its speed, can play important roles in all modern business and industry.

No, this is not the "doodling" of a man on the telephone. Far from it. It's the photographic record of an oscilloscope trace that shows, and times, detonation in a "knocking" engine. It all happens in a few hundred-thousandths of a second—yet photography gets it clearly and accurately as nothing else can.

Oscillograph recording is but one of countless functional uses of photography in bettering products and improving manufacturing methods. High speed "stills" can freeze fast action at just the crucial moment—and the design or operation of a part can be adjusted to best advantage.

And high speed movies can expand a second of action into several minutes so that fast motion can be slowed down for observation—and products be made more dependable, more durable.

Such uses of photography—and many more—can help you improve your product, your tools, your production methods. For every day, functional photography is proving a valuable and important adjunct in more and more modern enterprises.

Eastman Kodak Company, Rochester 4, N. Y.

Functional Photography

. . . is advancing business and industrial technics

Kodak
TRADE-MARK

8 reasons why college graduates at G.E. find work that they like

"In seeking to place college graduates in jobs they will enjoy doing," M. M. Boring, manager of the Technical Personnel Divisions, said recently, "we at General Electric find our work made easy by the diversification of the company's business.

"We tell a newcomer to look around, to work in several different fields, to try to determine where he will be most satisfied. The company's eight Operating Departments, ranging from Chemical to Apparatus, from the making of lamps to the building of big turbines and electric locomotives, give him plenty of room for his search.

"Engineers, chemists, physicists, and mathematicians, as well as liberal arts graduates, all find work here that they can be interested in and can do with enthusiasm.

"Their ability to find satisfying jobs with us is, we feel, an important factor in keeping General Electric ahead in electrical research, engineering, and manufacturing."

You can put your confidence in—

GENERAL ELECTRIC